Project Manual

Dzilth-Na-O-Dith-Hle Community School

Bloomfield, New Mexico

December 4, 2020

CONSTRUCTION DOCUMENTS

VOLUME 2

fbt architects

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DIVISION 28 – ELECTRONIC SAFETY & SECURITY

DIVISION 31 – EARTHWORK

DIVISION 32 – EXTERIOR IMPROVEMENTS

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DZILTH-NA-O-DITH-HLE
COMMUNITY SCHOOL

SECTION 21 0500 - COMMON WORK REQUIREMENTS FOR FIRE SUPPRESSION

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. See General Conditions and Supplemental General Conditions.

B. The requirements listed under General Conditions and Supplemental General Conditions and the General Requirements are applicable to this section and all subsequent sections of Division 21 and form a part of the contract.

C. Division 22 for Plumbing Systems.

D. Division 23 for Heating, Ventilating and Air Conditioning (HVAC) Systems.

E. Division 26 for Electrical Systems.

F. Division 28 for Fire Alarm Systems.

G. Division 31, for Trenching, Backfilling and Compaction requirements.

H. Division 33 for requirements of site utility systems, including sanitary sewer, storm sewer, domestic water distribution system, fire main water distribution system, and natural gas service.

I. All electrical work, regardless of voltage which is provided under Division 21 shall comply with the requirements of the National Electric Code (NEC) and Division 26.

1.2 FIRE SUPPRESSION DIVISION INDEX

Section 21 0500	Common Work Requirements for Fire Suppression
Section 21 0503	Trenching and Backfilling for Fire Suppression
Section 21 0504	Pipe and Pipe Fittings for Fire Suppression
Section 21 0505	Piping Specialties for Fire Suppression
Section 21 0523	Valves for Fire Suppression
Section 21 0548	Vibration & Seismic Controls
Section 21 0549	Fire Suppression and Electrical Installation Coordination
Section 21 1313	Fire Protection System, Automatic Wet Pipe Sprinkler

1.3 CODES AND PERMITS

A. The fire suppression shall be performed in strict accordance with the applicable provisions of the International Building Code, 2015 Edition; the Uniform Plumbing Code, 2012 Edition; the Uniform Mechanical Code, 201209 Edition and the International Fire Code, 2015 Edition and the National Fire Protection Association Pamphlet 5000 (NFPA Regulations), current adopted edition, regarding fire protection, heating and ventilating and air conditioning systems and electrical systems. All materials and labor necessary to comply with rules, regulations and ordinances shall be provided. Where the drawings and/or specifications indicate materials or construction in excess of code requirements, the drawings and/or specifications shall govern. The Contractor shall hold and save the Architect and Engineer free and harmless from liability of any nature or kind arising from his failure to comply with codes and ordinances.

B. Permits necessary for performance of the work shall be secured and paid for by the Contractor. See Division 33 for all requirements associated with utility permits and fees, connections and extensions.

C. The following lists some applicable codes and standards that shall be followed.

Applicable county and state mechanical, electrical, gas, plumbing, health and sanitary codes, laws and ordinances

National Electrical Manufacturer's Association Standards

National Electrical Code

Underwriters Laboratories, Inc. Standards

American National Standards Institute

American Society for Testing Materials Standards

Standards and requirements of local utility companies

National Fire Protection Association Standards

American Society of Mechanical Engineers Boiler and Pressure Vessel Codes

Occupational Safety and Health Act

The American Society of Sanitary Engineering

1.4 RECORD DRAWINGS

A. See Division 1, for requirements associated with Project Record Drawings.

B. The Contractor shall be responsible to maintain a complete and accurate set of marked up blue-line prints showing information on the installed location and arrangement of all mechanical

work, and in particular, where changes were made during construction. The Contractor shall be responsible for keeping record drawings accurate and up-to-date throughout the construction period. Record drawings may be reviewed and checked by the Architect, Engineer or Owner's Representative during the construction and in conjunction with review and approval of monthly pay requests. The Contractor shall include copies of all addenda, RFI's, bulletins, and change orders neatly taped or attached to record drawing set.

C. After installation and acceptance of direct buried underground piping and service lines in trenches, the Contractor shall take 'as-built' measurements, including all depths, prior to commencement of backfilling operations. It will not be sufficient to check off line locations. Definite measurements shall be taken for each service line. The location of buried piping and trench service lines shall be shown on the drawings and dimensioned from fixed points.

1.5 QUALIFICATIONS

A. All mechanics shall be skilled in their respective trade.

B. All welders shall be certified in accordance with the ASME Boiler Test Code, Section IX, latest issue.

1.6 QUALIFICATION PROCEDURES

A. The storage, handling, and transportation of all refrigerants, oils, lubricants, etc. shall be accomplished in strict compliance with all State, local, and Federal Regulations including all requirements set forth by the Environmental Protection Agency (EPA) for the safe handling of regulated refrigerants and materials. The Contractor shall utilize qualified and/or certified personnel and equipment as prescribed by these requirements.

1.7 HAZARDOUS CONDITIONS

A. Protruding metal (bolts, steel angles, etc.) potentially hazardous to maintenance and operation personnel, shall be cut back and/or protected to reduce the risk of injury.

1.8 HAZARD SIGNS

A. Equipment rooms, fan plenums, and similar areas containing moving or rotating parts, or other potentially hazardous environments shall include signs on all doors entering such spaces that shall read similar to the following: "Hazardous Area - Authorized Personnel Only."

B. Confined Spaces: Areas designated by OSHA Standard 1910.146 as a confined space shall be marked with a sign that reads "Confined Space - Entry by authorized personnel only, by permit."

1. "Confined Space" means a space that:

a. Is large enough and so configured that an employee can bodily enter and perform assigned work; and
b. Has limited or restricted means for entry or exit (for example, tanks, vessels, storage bins, hoppers, vaults, and pits are spaces that may have limited means of entry); and
c. Is not designed for continuous employee occupancy.

C. The Contractor shall survey the final premises to determine where any such potentially hazardous areas exist. If the Contractor feels that hazards exist which cannot be suitably provided for through the above typical methods, he shall forward in writing his concerns, and request for a decision concerning the referenced hazard, prior to the final inspection of the facilities.

1.9 SUBMITTALS

A. The Contractor shall submit submittal brochures of all equipment, fixtures and materials to be furnished under Division 21, including but not limited to the following:

1. Piping materials, valves, equipment and installation methods, vibration isolation devices, pipe penetration installation methods and products for fire rated assemblies, and all equipment listed on equipment schedules, and in related construction documents.
2. Materials, certification, shop drawings, and other information as specified in the individual Division 21 Specification Sections within this Specification.

B. Unauthorized Substitutions: If substitute materials, equipment or systems are installed without prior review or are installed in a manner which is not in conformance with the requirement of this Specification and for which the Contractor has not received a written review, removal of all the unauthorized materials and installation of those indicated or specified shall be provided at no change in contract amount.

C. All equipment shall be installed in accordance with the manufacturer's recommendations. Provide all accessories and components for optimum operation as recommended by the manufacturer.

D. Expense: All costs for the preparation, correction, delivery, and return of the submittals shall be borne by the Contractor.

E. See Division 1 for additional submission requirements.

F. Complete data must be furnished showing performance, quality and dimensions. No equipment or materials shall be purchased prior to receiving written notification that submittals have been reviewed and marked either "NO EXCEPTIONS TAKEN" or "EXCEPTIONS AS NOTED."

Submittals returned marked "EXCEPTIONS AS NOTED" do not require resubmittal provided that the Contractor agrees to comply with all exceptions noted in the submittal, and so states in a letter.

G. Review of Submittals: Submittals will be reviewed with reasonable promptness, but only for conformance with the design concept of the Project and for conformance with the information indicated on the Drawings and stated in the Specifications. Review of a separate item as such will not indicate review of the assembly in which the item functions. Review of submittals shall not relieve the Contractor of responsibility for any deviation from the requirements of the Contract Documents, nor for errors or omissions in the submittals; or for the accuracy of dimensions and quantities, the adequacy of connections, and the proper and acceptable fitting, execution, functioning and completion of the work. Review shall not relieve the Contractor of responsibility for the equipment fitting within the allotted space shown on the drawings with all clearances required for equipment operation, service and maintenance including minimum clearances required by applicable codes, manufacturer's installation instructions and as necessary for proper clearance in front of all electrical panels as defined by the National Electric Code (NEC). Any relocation of mechanical and/or electrical equipment, materials and systems required to comply with minimum clearances shall be provided by the Contractor without additional cost under the Contract.

H. Shop drawings will be returned unchecked unless the following information is included: cover sheet shall be provided for each submittal of equipment, products and material proposed for use on the project. A common cover sheet for similar equipment (example: all air handling units or all fire protection products) is acceptable. The cover sheet shall list equipment by symbol number; reference all pertinent data in the Specifications or on the drawings; provide size and characteristics of the equipment, name of the project and a space large enough to accept a review stamp. The data submitted shall reflect the actual equipment performance under the specified conditions and shall not be a copy of the scheduled data on the drawings. Cover sheet shall clearly identify any deviations from the specifications for submitted equipment, products, and materials.

I. Use of substitutions reviewed and checked by the Engineer does not relieve the Contractor from compliance with the Contract Documents. Contractor shall bear all extra expense resulting from the use of any substitutions where substitutions affect adjoining or related work required in this Division or other Divisions of this Specification.

J. If Contractor substitutes equipment for that drawn to scale on the drawings, he shall prepare a 1/4" = 1'-0" installation drawing for each equipment room where a substitution is made, using dimensions of substituted equipment, and including piping, and electrical equipment requirements, to verify that equipment will fit space with adequate clearances for maintenance. This 1/4" = 1'-0" fabrication drawing shall be submitted for review with the shop drawing submittals of the substitution. Failure to comply with this requirement will result in the shop drawings being returned unchecked.

1.10 COORDINATION DRAWINGS

A. The Contractor shall, in advance of the work, prepare coordination drawings for:

1. Mechanical equipment rooms.
2. Piping and piping chases.
3. Complete fire suppression system piping and sprinkler head layout.
4. Layout of all fire suppression equipment.
5. Corridors.

B. Show the location of piping openings through the building floors, walls and roofs coordinated with Architectural and Structural, as well as the location and elevations of building fire suppression equipment and systems and piping, coordinated with plumbing, HVAC and electrical systems. Coordination drawings, including plans, elevations and sections, as appropriate, shall clearly show the manner in which the fire suppression systems fit into the available space and coordinates with HVAC and plumbing equipment, ductwork, piping, and electrical equipment, including conduits, light fixtures, motor control centers, transformers, panels, variable frequency drives, etc. Drawings shall demonstrate required code clearances for mechanical and electrical equipments, control panels, etc., and proper operation, maintenance and replacement of fire suppression devices and equipment. Coordination drawings shall be of appropriate scale to satisfy the previously stated purposes, but not smaller than 1/8 inch scale for floor plans and 1/4 scale of equipment rooms and chase areas. Drawings may be composite or may be separate but fully coordinated drawings of the same scale. Every subcontractor must sign-off on coordination drawings prepared by each craft. Failure to sign-off will indicate that subcontractor is proceeding at his own risk. Any cost required to relocate systems to comply with required clearance and equipment installation requirements shall be provided by the Contractor without additional cost under the contract.

C. Seven (7) complete sets of coordination drawings shall be submitted prior to the scheduled start of the work in the area illustrated by the drawings, for the purpose of showing the Contractor's planned method of installation. The objectives of such drawings are to promote carefully planned work sequence and proper coordination, in order to assure the expeditious solutions of problems, and the installation of lines and equipment as contemplated by the contract documents while avoiding or minimizing additional costs to the Contractor and to the Owner.

D. In the event the Contractor, in coordinating the various installations and in planning the method of installation, finds a conflict in location or elevation of any of the mechanical systems, with the structural items or with other construction items, such conflicts shall immediately be documented and submitted for clarification. In doing so, the Contractor shall explain the proposed method of solving the problem, or shall request instructions as to how to proceed if adjustments beyond those of usual trades coordination are necessary.

E. Installation of fire suppression work shall not proceed prior to the submission and completion of the review of the coordination drawings, and any conflicts which are disclosed by the coordination drawings. It is the responsibility of the Contractor to submit the required drawings in a timely manner consistent with the requirements for completing the work covered by this contract within the prescribed contract time.

1.11 USE OF CADD FILES

A. Under certain conditions, the Contractor will be permitted the use of the Engineer's CADD files for documentation of as-builts, submittals, or coordination drawings.

B. The Engineer may require compensation for the time necessary to format the CADD files delivery to the Contractor. Such work will include removal of title blocks, professional for seals, calculations, proprietary information, etc.

C. The Contractor shall complete the enclosed License, Indemnity and Warranty Agreement, complete with contractor's name, address, and Contractor's Representative signature prior to request for CADD file usage.

1.12 PRIOR APPROVAL

A. Equipment manufacturers and service providers are listed within the specifications for the work specified in this division. For the items listed below, the specified manufacturers and providers are the only ones presently approved, and may be the only ones allowed:

1. Plumbing Fixtures and Trim

B. Manufacturers and service providers who are not listed in these specs, and who offer equivalent or superior products or services, are invited to submit for approval prior to bid (prior approval). Submit two copies. Requests for prior approval must:

1. Include the substitution request form at the end of this spec section.
2. Include technical data sufficient for the Engineer to generally assess appropriateness for this project.
3. Be submitted minimum ten days prior to the bid date in effect at the time of submission.
4. Comply with any additional requirements per specification Division 1.

C. Any additional prior approved alternate manufacturers and service providers will be published in an addendum prior to bid. Prior approval indicates that based on the information submitted it appears to the Engineer that the alternate might be capable of meeting the specifications and the design intent, and might be appropriate for the project. But prior approval does not guarantee this. Prior approved products and service providers must still go through the submittal process after award, and must still comply with the design intent and all specification requirements.

D. Please do not request prior approval for products and service providers that are not listed above. Instead, for those items alternate manufacturers and alternate service providers may be submitted after bid in accordance with the submittal process, provided they meet or exceed the specifications and the indicated design intent.

1.13 GUARANTEE-WARRANTY

A. See Division 1 for additional warranty requirements.

B. The following guarantee is a part of the specifications and shall be binding on the Contractor:

> "The Contractor guarantees that this installation is free from mechanical defects. He agrees to replace or repair any part of the installation which may fail within a period of one year after date established below, provided that such failure is due to defects in the materials or workmanship or to failure to follow the specifications and drawings. Warranty of the Contractor-furnished equipment or systems shall begin on the date the system or equipment is placed in operation for beneficial use of the Owner or occupancy by the Owner, whichever occurs first; such date will be determined in writing, by means of issuing a 'Certificate of Substantial Completion', AIA Form G704," or equivalent.

C. The extent of guarantees or warranties by Equipment and/or Materials Manufacturers shall not diminish the requirements of the Contractor's guarantee-warranty to the Owner.

D. All items of fire suppression equipment shall be provided with a full one (1) parts and labor warranty, from the date of acceptance by the Owner.

PART 2 - PRODUCTS

2.1 QUALITY OF MATERIALS

A. All equipment and materials shall be new, and shall be the standard product of manufacturers regularly engaged in the production of fire suppression equipment and shall be the manufacturer's latest design. Specific equipment, shown in schedules on drawings and specified herein, is to set forth a standard of quality and operation.

B. Hazardous or Environmentally Damaging Materials: Products shall not contain asbestos, mercury, PCBs, or other materials harmful to people or the environment.

2.2 ELECTRICAL WIRING AND CONTROL EQUIPMENT

A. All wiring and conduit shall be furnished and installed as scheduled in Section 210549, Fire Suppression and Electrical Installation Coordination, unless otherwise noted or directed.

B. The Contractor shall coordinate completely with all trades and Sub-Contractors as required to ensure that all necessary components of control work are included and fully understood. No additional cost shall accrue to the Owner as a result of lack of such coordination.

C. The fire suppression piping system may be bonded to the electrical ground bus at the electrical service equipment, but shall not under any circumstances be used as the main grounding electrode for the electrical service.

2.3 PAINTING

A. All finish painting of fire suppression systems and equipment will be under "Painting," unless equipment is hereinafter specified to be provided with factory applied finish coats.

B. All equipment shall be provided with factory applied prime finish, unless otherwise specified.

C. Touch-Up: If the factory finish on any equipment is damaged in shipment or during construction of the building, the equipment shall be refinished.

2.4 IDENTIFICATION OF VALVES

A. Each valve installed under this contract shall be provided with a stamped metal tag secured to the valve. Tag shall indicate the valve number, the service and function of each valve. The Contractor shall furnish two sets of prints of drawings showing floor plan for each floor with all valves accurately located and labeled. Submitted drawings shall be neat and easily readable. In addition, the Contractor shall provide a valve chart, typed neatly on 8-1/2" x 11" sheets, listing the number, size, location, function, normal operating position, on each valve installed under Division 21. Tags shall be stamped brass 1-1/2" diameter, and secured to valves by heavy copper figure eight hooks, braided stainless steel wire anchor, or other approved means.

B. Division 21 valve tags shall be coordinated with Division 22 and Division 23 valve tags for coordinated format between each division.

C. Valve tags shall be coordinated with existing facility valve tags and Contractor shall obtain a copy of existing facility valve chart and provide updated valve chart to the Owner's Representative.

2.5 PIPING SYSTEM IDENTIFICATION

A. Means of Identification: All piping shall be identified by each of the means described below. The Contractor shall provide shop drawing submittal data for proposed labeling system materials and manufacturer's recommended installation procedures.

B. Piping Systems shall be identified by means of an identifying legend on color coded background appropriately worded to indicate the "service" name of the pipe as shown on the drawings. Color coded banding shall also be provided. Additionally, an arrow shall be included to indicate the direction of flow through the pipe.

C. Locations of Piping System Identification: The identifying legends and directional arrows described in the paragraphs preceding shall be located at the following points on each piping system:

- Adjacent to each valve in piping system.
- At every point of entry and exit where piping passes through a wall.
- On each pipe riser and junction.
- At a maximum interval of 20 feet on pipe lines exposed and concealed above accessible ceilings.
- Adjacent to all special fittings (regulating valves, etc.) in piping systems.

- At every access door.

D. Piping identification shall meet the standards of the Federal Occupational Safety Health Act (OSHA) which refers to the ANSI Standard A13.1. The following standardized color code scheme shall be used:

Yellow - Hazardous Materials
Green - Liquid Materials of Inherently Low Hazard
Blue - Gaseous Materials of Inherently Low Hazard
Red - Fire Protection Materials

E. The size of letter and length of color field shall conform to the ANSI standard and shall be as follows:

Outside Diameter of Pipe or Covering	Length of Color Field	Size of Letters
3/4" to 1-1/4"	8"	1/2"
1-1/2" to 2"	8"	3/4"
2-1/2" to 6"	12"	1-1/4"
8" to 10"	24"	2-1/2"
Over 10"	32"	3-1/2"

F. All pipe labels except pipe labels located exposed within the mechanical equipment spaces shall be vinyl material with permanent adhesive for application to clear dry pipe and/or insulation jacketing. Each label shall have appropriate color-coded background with printed legend. Direction arrows shall be placed next to label to indicate flow direction. Color and size of arrows shall correspond to that of label. Pressure sensitive pipe tape matching the ackground color of the label shall be placed over each end of the label and completely around the pipe.

G. Attach pipe markers to lower quarter of the pipe on horizontal runs and on the centerline of vertical piping where view is not obstructed. Flow indicator arrow shall point away from pipe marker.

H. Provide the following labels, with ANSI/OSHA color for all piping systems as shown on the drawings and as listed below:

Service/Legend	Letter Color	Background Color
Fire Protection Water	White	Red
Fire Auto Sprinkler	White	Red
Fire Wet Standpipe	White	Red

2.6 IDENTIFICATION OF CONTROL SYSTEM DEVICES

A. All automatic controls, control panels, pressure electric, electric pressure switches, relays and starters shall be clearly tagged and identified.

2.7 UNDERGROUND PIPING SYSTEM IDENTIFICATION

A. Bury a continuous, preprinted, bright colored, plastic ribbon cable marker with each underground pipe regardless of whether encased. Locate directly over buried pipe, 6" to 8" below finished grade. Marker tape used in conjunction with buried plastic piping systems shall be special detector type. Marker tape used in conjunction with buried plastic piping systems shall be special detection type.

2.8 ACCESS DOORS

A. Provide all access doors required for access to valves, controls, or other items for which access is required for either operation or servicing. All costs incurred through failure to perform this function as the proper sequence of this work shall be borne by the Contractor. The type of access door shall be as required by the room finish schedule. Acoustical tile access doors shall be equal to Krueger Style B, Style A for acoustical plaster, Style C-CE for sidewall drywall or plaster construction[, or Milcor institutional 10 gauge security/detention access door with welded joints, welded butt hinge, with detention type deadbolt lock and tamperproof screws.

B. Access doors shall be not less than 12" x 12" in size except that larger panels shall be furnished where required, and panels in tile or other similar patterned ceilings shall have dimensions corresponding to the tile or pattern module.

C. Where access doors are installed in walls required to have a specific fire rating, the access door installed shall be a fire rated access door with UL label, as manufactured by Milcor or equivalent. Access door in 1-hour construction shall be Class C and access doors in 2-hour construction shall be Class B.

PART 3 - EXECUTION

3.1 COOPERATION WITH OTHER TRADES

A. The Contractor shall refer to other parts of these specifications covering the work of other trades which must be carried on in conjunction with the mechanical work so that the construction operations can proceed without harm to the Owner from interference, delay, or absence of coordination. The Contractor shall be responsible for the size and accuracy of all openings.

3.2 DESIGN AND DRAWINGS

A. The complete design for the project fire suppression system including drawings, hydraulic calculations, piping sizing and arrangement, head layouts, equipment selection, etc., shall be the responsibility of Division 21 Contractor. Preparation of the fire suppression system design shall be in accordance with all Division 21 specification requirements, NFPA 5000 requirements and Authorities Having Jurisdiction.

B. The fire suppression drawings show the general arrangement of piping, equipment, etc., and shall be followed as closely as actual building construction and work of other trades will permit. Whenever discrepancies occur between plans and specifications, the most stringent shall govern. All Contract Documents, including but not limited to Division 22 Plumbing, Division 23 Heating Ventilating and Air Conditioning and Division 26 electrical shall be considered as part of the work insofar as this information furnishes the Contractor with details relating to design and construction of the building. Architectural and structural drawings shall take precedence over the fire suppression, plumbing, HVAC and electrical drawings. Because of the small scale of the fire suppression drawings, it is not possible to indicate all offsets, fittings and accessories which may be required. The Contractor shall investigate the structural and finish conditions affecting the work and shall arrange his work accordingly, providing such fittings, valves, and accessories as may be required to meet such conditions. Should conditions necessitate a rearrangement of piping, such departures and the reasons therefore shall be submitted by the Contractor for review in the form of detailed drawings showing the proposed changes. No such changes shall be made without the prior written approval. All changes shall be marked on the set of record drawings by the Contractor.

C. Should any doubt or question arise in respect to the true meaning of the drawings or specifications, the question shall be submitted in writing.

D. Installation of all fire suppression equipment and piping systems shall be arranged to provide all clearances required for equipment operation, service, and maintenance, including minimum clearances required by applicable codes, manufacturer's installation instructions and as necessary for proper clearance in front of all electrical panels as defined by the National Electric Code (NEC). Piping systems shall not be routed through or above electrical equipment room or electrical equipment space designed within mechanical equipment rooms.

E. The Contractor's attention is directed to the unique architectural design features and consideration associated with this facility which will require significantly greater levels of coordination and cooperation for the work furnished and installed under Division 21 with the associated architectural, structural, and electrical work than is normally necessary for a more typical facility.

F. The installation of all concealed fire suppression systems shall be carefully arranged to fit within the available space without interference with adjacent mechanical, plumbing, structural and electrical systems. The Contractor shall make all necessary provisions for penetrations of piping, including sleeves and blockouts in structural systems. The exact location of all exposed fire suppression systems, including access doors; sprinkler piping exposed within finished areas; and other equipment and devices as applicable, shall be coordinated with the Architect, who shall have final authority for the acceptance of the work as it specifically relates to the architectural aesthetic design requirements for the facility. In no instance shall the building vapor barrier system be penetrated by the fire suppression system installation without written approval.

3.3 FIELD MEASUREMENTS

A. The Contractor shall verify the dimensions and conditions governing his work at the building. No extra compensation shall be claimed or allowed on account of differences between actual dimensions, including dimensions of equipment, fixtures and materials furnished, and those indicated on the drawings. Contractor shall examine adjoining work, on which his work is dependent for perfect efficiency, and shall report any work which must be corrected. Coordination of all fire suppression work within the building will be the direct responsibility of the Contractor. Review of submittal data in accordance with paragraph "Submittals" shall in no manner relieve the Contractor of responsibility for the proper installation of the fire suppression work within the available space. Installation of equipment and systems within the building space shall be carefully coordinated by the Division 21 Contractor with all building trades. Each contractor shall so harmonize his work with that of the several other trades that it may be installed in the most direct and workmanlike manner without hindering or handicapping the other trades. Piping interferences shall be handled by giving precedence to pipe lines which require a stated grade for proper operation. Sewer lines shall take precedence over water lines in determination of elevations. In all cases, lines requiring a stated grade for their proper operation shall have precedence over electrical conduit and ductwork. Installation of fire suppression, plumbing and HVAC systems within the ceiling cavity shall be in the following order of priority: plumbing waste lines; roof drains; supply, return, outside air, makeup, and exhaust ductwork; fire sprinkler mains; fire sprinkler branch piping and sprinkler runouts; heating hot water and chilled water piping; domestic hot and cold water; control piping, wiring and conduit; miscellaneous special piping systems..

3.4 EQUIPMENT SUPPORT

A. Contractor shall provide support for equipment to the building structure. Contractor shall furnish all necessary structures, inserts, sleeves, and hanging devices for installation of mechanical and plumbing equipment, ductwork and piping, etc. Contractor shall completely coordinate installation of such devices with all trades and Sub-Contractors. Contractor must further verify that the devices and supports are adequate as intended and do not overload the building's structural components in any way.

3.5 SEISMIC SUPPORTS

A. The Contractor shall be responsible for all anchors and connections for the mechanical work to the building structure to prevent damage of equipment and systems due to earthquakes. The complete fire protection systems shall be supported as required to resist stresses produced by lateral forces as required by NFPA No. 13 and 5000. Where fire suppression equipment and piping is connected to the building structure, exact method and means of attachment to the structural system shall be approved by the Architect and Owner's Representative.

3.6 PROTECTION OF MATERIALS AND EQUIPMENT

A. The Contractor shall be responsible for the protection of all work, materials and equipment furnished and installed under this section of the specifications, whether incorporated in the building or not.

B. Fire suppression equipment and materials, including piping, valves and fittings, etc., shall be protected from damage and contamination. Equipment and materials shall not be stored outside and exposed to weather and ambient conditions without appropriate protection measures and without the approval of the Architect and Owner's Representative. Equipment shall be delivered to the jobsite and maintained while on the jobsite with all openings, controls and control panels covered with heavy duty polyethylene wrap or other proper means. Equipment and materials where stored within the building shall be protected at all times from construction damage and contamination from dust, dirt, debris, and especially during fireproofing, painting and gypboard sanding and finishing. Unprotected equipment and piping will require special field cleaning by the Contractor prior to acceptance by the Architect. and Owner's Representative.

C. The Contractor shall provide protection for all work where necessary and shall be responsible for all damage done to property, equipment and materials. Storage of materials within the building shall be approved by the Architect and Owner's Representative prior to such storage.

D. Pipe openings shall be closed with caps or plugs, or covered to prevent lodgment of dirt or trash during the course of installation. At the completion of the work, fire suppression equipment and materials shall be cleaned thoroughly and delivered in a condition satisfactory to the Architect, Engineer and Owner's Representative.

3.7 TRENCHING AND BACKFILLING

A. All excavation, trenching and backfilling required for the fire suppression installation shall be provided by this Contractor.

3.8 MANUFACTURER'S INSTRUCTIONS

A. All equipment shall be installed in strict accordance with recommendations of the manufacturer. If such recommendations conflict with plans and specifications, the Contractor shall report such conflicts to the Architect who shall make such compromises as he deems necessary and desirable.

3.9 TESTS

A. Tests shall be conducted in the presence of the designated and authorized Owner's Representative. The Contractor shall notify the Architect and Owner's Representative a minimum of one week in advance of scheduled tests. Requirements for testing are specified under the sections covering the various systems. The Contractor shall furnish all necessary equipment, materials, and labor to perform the required tests.

3.10 OPERATION AND MAINTENANCE INSTRUCTIONS

A. The Contractor shall furnish complete operating and maintenance instructions covering all units of fire suppression equipment herein specified together with parts lists. Equipment spare parts shall include all components requiring service, including motors, bearings, shafts, etc. Furnish four (4) copies of all the literature; each shall be suitably bound in loose leaf book form. A "Lubrication Chart" framed under plexiglass shall be provided listing all types of oil to be used for each piece of equipment and the recommended frequency of lubrication. This chart shall be hung on the wall of the equipment room.

B. See Division 1 for additional requirements concerning manuals, manual distribution, and maintenance materials.

C. Operating and maintenance manuals as required herein shall be submitted for review and distribution to the Owner not less than two (2) weeks prior to the date scheduled for the Contractor to provide Operating and Maintenance Instructions to the Owner as specified herein.

D. Upon completion of all work and all tests, the Contractor shall instruct the Owner or his representative fully in the operations, adjustment and maintenance of all equipment furnished. Contractor shall provide at least two weeks notice in advance of this period, with a written schedule of each training session, the subject of the session, the Contractors' representatives who plan to attend the session, and the time for each session.

3.11 CERTIFICATIONS

A. Before receiving final payment, the Contractor shall certify in writing that all equipment furnished and all work done is in compliance with the contract documents and all applicable codes. Submit certifications and acceptance certificates, including proof of delivery of O&M manuals, spare parts required, and equipment warranties which shall be bound with O&M manuals.

3.12 SITE VISITS AND OBSERVATION OF CONSTRUCTION

A. The design professional shall make periodic visits to the project site at various stages of construction in order to observe the progress and quality of various aspects of the Contractor's work, in order to determine in general if such work is proceeding in accordance with the Contract Documents. This observation, however, shall in no way release the Contractor from his complete responsibility to supervise, direct, and control all construction work and activities. The design team has no authority over, or a responsibility to means, methods, techniques, sequences, or procedures of construction provided by the Contractor or for safety precautions and programs, or for failure by the Contractor to comply with all law, regulations, and codes.

END OF SECTION 21 0500

DIVISION 21 SUBSTITUTION REQUEST FORM (SRF)

TO: **BRIDGERS & PAXTON CONSULTING ENGINEERS, INC.**
PROJECT: _____

We hereby submit for your consideration the following product instead of the specified item for the above project:
Section: _____ Page: _____ Paragraph/Line: _____ Specified Item: _____
Proposed Substitution: _____

Attach complete product description, drawings, photographs, performance and test data, and other information necessary for evaluation. Identify specific Model Numbers, finishes, options, etc.

1. Will changes be required to building design in order to properly install proposed substitutions? YES ☐ NO ☐
   If YES, explain: _____

2. Will the undersigned pay for changes to the building design, including engineering and drawing costs, caused by requested substitutions? YES ☐ NO ☐

3. List differences between proposed substitutions and specified item.

Specified Item	Proposed Substitution
_____	_____
_____	_____
_____	_____

4. Does substitution affect Drawing dimensions? YES ☐ NO ☐

5. What affect does substitution have on other trades? _____

6. Does the manufacturer's warranty for proposed substitution differ from that specified? YES ☐ NO ☐
   If YES, explain: _____

7. Will substitution affect progress schedule? YES ☐ NO ☐
   If YES, explain: _____

8. Will maintenance and service parts be locally available for substitution? YES ☐ NO ☐
   If YES, explain: _____

9. Does proposed product contain asbestos in any form? YES ☐ NO ☐

SUBMITTED BY: Firm: _____ Date: _____
Address: _____
Signature: _____ Telephone: _____

For Engineer's Use Only
Accepted _____ Not Accepted: _____ Received too Late: _____
By: _____ Date: _____
Remarks: _____

LICENSE AGREEMENT FOR CADD DATABASE OR BIM MODEL

PROJECT: _____

LICENSE GRANT: Contractor is granted use of the CADD Database or BIM Model (Database/Model) for the indicated project for the specific purpose of preparing submittal documents for this Project. No other use of the Database/Model is granted. Title to the Database/Model is not transferred to the Contractor. The Database/Model may be of value to the Contractor in preparing submittals, but use of the model does not relieve the contractor of the requirement to verify measurements in the field.

COPYING RESTRICTIONS: Contractor may copy the Database/Model in whole or in part, but only for backup and archival purposes or for use by the Contractor's Subcontractors. Contractor agrees to ensure that any entities that receive the Database/Model from Contractor, either in whole or in part, comply with the terms and conditions of this agreement. Contractor shall safeguard the Database/Model from falling into the hands of parties other than Subcontractors with a legitimate need for it.

WARRANTY: Bridgers & Paxton (B&P) offers this Database/Model without warranty and specifically without express or implied warranty of fitness. If Contractor chooses to use the Database/Model, then he does so at his own risk and without any liability or risk to B&P.

INDEMNITY: Contractor shall to the fullest extent permitted by law, defend, indemnify and hold harmless the Owner, Architect, B&P, their employees and agents from all claims, damages, losses, and attorney fees arising out of or resulting from the use of the Database/Model.

ACKNOWLEDGMENT: Contractor acknowledges that (s)he has read this Agreement, understands it, and agrees to be bound by its terms and conditions.

CONTRACTOR'S REPRESENTATIVE

Signature: _____ Company Name: _____

Name: _____ Address 1: _____

Title: _____ Address 2: _____

Date: _____

SECTION 21 0503 - TRENCHING AND BACKFILLING FOR FIRE SUPPRESSION

PART 1 - GENERAL

1.1 REQUIREMENTS

A. Conform with applicable provisions of the General Conditions, Supplemental General Conditions and the General Requirements.

1.2 SCOPE OF WORK

A. The work in this section includes the furnishing of all labor, materials, equipment, transportation, hauling and services required in connection with the excavation, backfilling, compaction, grading and removal of earth from the site required for the installation of the mechanical work specified herein under Division 21.

1.3 SAFETY REGULATIONS

A. All work performed under this Section shall conform to the requirements of the General Conditions, Supplemental General Conditions and Safety Requirements for this type of work.

PART 2 - PRODUCTS

Not Applicable.

PART 3 - EXECUTION

See Division 23, Section 230503, for applicable requirements.

END OF SECTION 21 0503

SECTION 21 0504 - PIPE AND PIPE FITTINGS FOR FIRE SUPPRESSION

PART 1 - GENERAL

1.1 REQUIREMENTS

A. Conform with applicable provisions of the General Conditions, Supplemental General Conditions and General Requirements.

B. Lead Ban: All piping, solder and flux used in the installation of piping systems furnished and installed under Division 21, shall be lead free. The term lead free is defined as pipe which does not contain more than 8.0% lead and solder and flux which does not contain more than 0.2% lead.

1.2 RELATED SECTIONS

A. Section 210500 for Common Work Requirements for Fire Suppression.

1.3 SUBMITTAL DATA

A. Contractor shall furnish complete submittal data for all piping materials, including manufacturer's specifications, certifications, class, type and schedule. Submittal data shall additionally be furnished for pipe hangers and supports, pipe sleeves including sealing and fire safing materials and installation.

PART 2 - PRODUCTS

See Division 23, Section 230504, for applicable requirements.

PART 3 - EXECUTION

See Division 23, Section 230504, for applicable requirements.

END OF SECTION 21 0504

SECTION 21 0505 - PIPING SPECIALTIES FOR FIRE SUPPRESSION

PART 1 - GENERAL

1.1 REQUIREMENTS

A. Contractor shall furnish and install all piping specialties necessary for satisfactory operation of the systems. Conform with applicable provisions of the General Conditions, Supplemental General Conditions and General Requirements.

1.2 RELATED SECTIONS

A. Section 210500, Common Work Requirements for Fire Suppression.

B. Section 210503, Trenching and Backfilling for Fire Suppression.

C. Section 210504, Pipe and Pipe Fittings for Fire Suppression.

D. Section 210523, Valves for Fire Suppression.

E. Section 210549, Fire Suppression and Electrical Installation Coordination.

F. Section 211313, Fire Protection System, Automatic Wet-Pipe Sprinkler

1.3 SUBMITTAL DATA

A. Contractor shall furnish complete submittal data for all piping specialties including manufacturer's specifications, performance characteristics, ratings, installation instructions, certifications and approvals of listing agencies, wiring diagrams, and selection analysis.

PART 2 - PRODUCTS

See Division 23, Section 230505, for applicable requirements.

PART 3 - EXECUTION

See Division 23, Section 230505, for applicable requirements.

END OF SECTION 21 0505

SECTION 21 0523 - VALVES FOR FIRE SUPPRESSION

PART 1 - GENERAL

1.1 REQUIREMENTS

A. All Valves shall conform with current applicable provisions of the General Conditions, Supplemental General Conditions, and General Requirements.

B. All Valves shall meet the current MSS Specifications covering Bronze & Iron Valves. MSS-SP-80, MSS-SP-70, MSS-SP71, MSS-SP-85 where applicable.

C. Lead Ban: Valves shall be lead free. The term lead free is defined as valves which do not contain more than 8.0% lead.

1.2 RELATED SECTIONS

A. Section 210500, Common Work Requirements for Fire Suppression.

B. Section 210523, Valve Identification for Fire Suppression.

C. Section 210504, Pipe and Pipe Fittings for Fire Suppression.

D. Division 23 for Valves.

1.3 SCOPE

A. Contractor shall furnish and install all valves and accessories necessary for satisfactory operation of the systems.

1.4 VALVE REQUIREMENTS

A. All Fire Suppression system valves shall be UL Listed and FM Approved. See applicable fire suppression system specification sections for additional valve requirements, including hose threads, tamper switches, etc.

B. All Gate, Globe, Check, Ball valves shall be manufactured by Milwaukee, Nibco, Apollo, Stockham, Powell, Crane, Grinnell, or equivalent.

C. Butterfly valves shall be as manufactured by Milwaukee, W. C. Norris, Centerline, Crane, Demco, Keystone, Grinnell, Victaulic, Nibco, or Dezurik, or equivalent.

PART 2 - PRODUCTS

See Division 23, Section 230523, for applicable requirements.

PART 3 - EXECUTION

See Division 23, Section 230523, for applicable requirements.

END OF SECTION 21 0523

SECTION 21 0548 - VIBRATION AND SEISMIC CONTROLS FOR FIRE PROTECTION

PART 1 - GENERAL

1.1 REQUIREMENTS

A. Conform with the applicable provisions of the General Conditions, Supplemental General Conditions, and General Requirements.

1.2 RELATED SECTIONS

A. Section 21 0500, Common Works Requirements for Fire Suppression.

B. Section 21 0504, Pipe and Pipe Fittings.

C. Section 21 0900, Instrumentation and Control for Fire Suppression System.

1.3 SCOPE

A. It shall be understood that the requirements for seismic restraints are in addition to other requirements as specified elsewhere for the support and attachment of equipment and mechanical services, and for the vibration isolation of same equipment. Nothing on the project drawings or specifications shall be interpreted as justification to waive the requirements for seismic restraint as specified herein, shown on the drawings and required by Code.

B. The work under this section shall include furnishing all labor, materials, tools, appliances and equipment, and performing all operations necessary for the complete execution of the installation of seismic snubber restraint assemblies as shown, detailed and/or scheduled on the drawings and/or specified in this section of the specifications.

C. The materials and systems specified in this section shall be provided by the Contractor from a single Seismic Snubber Restraint Materials Manufacturer to assure sole source responsibility for the performance of the seismic restraints used.

D. The seismic snubber restraint materials manufacturer shall be responsible for detailed design for seismic supports, including calculation for size and attachment, signed and sealed by registered State of New Mexico Structural Engineer.

1.4 SUBMITTALS

A. See Section 21 0500 for general requirements for submittal materials. In addition to the requirements contained in Section 21 0500, provide submittal information for all products and materials covered under this Section of the Specifications as listed herein.

B. Furnish complete catalog data on all vibration isolators, restraints, and equipment vibration bases to be utilized for the project in order to establish compliance with the plans and specifications and all code requirements.

C. Furnish complete shop drawing information including construction details for all vibration bases; support points and anchor bolt requirements and locations; method of support for piping; method of isolation for piping passing through the building structure; and location and arrangement of seismic restraints.

D. Manufacturers not listed as approved in 'Part 2 - Products' must submit for prior approval in accordance with provisions contained in Section 23 0500.

E. Drawings shall be reviewed and certified by a registered Professional Engineer, with a minimum of five (5) years working experience in this field, certifying that the submitted seismic restraint system design and anchorage details complies with all specification requirements and applicable codes.

1.5 CODE REQUIREMENTS

A. Seismic restraints shall be provided for equipment, materials and systems furnished and installed under Division 21 of this Specification in accordance with the requirements of the 2012 International Building Code; and NFPA No. 13 for fire protection system as adopted and interpreted by the State of New Mexico.

1.6 PROJECT SEISMIC PARAMETERS

A. The following parameters are based on Structural Calculations and should be used to evaluate the seismic requirements of the mechanical systems and components. See structural drawings for additional information:

Risk Category	**[IV]**
Seismic Response Coefficients	S_{DS}=**[0.546]** S_{D1}=**[0.167]**
Site Soil Class	**[C]**
Seismic Design Category	**[D]**

1.7 SEISMIC RESTRAINT REQUIREMENTS

A. The Contractor shall submit calculations prepared by a State of New Mexico licensed Structural Engineer to substantiate that all items of fire protection equipment and piping systems are properly supported to resist earthquake forces as required herein.

B. All fire protection equipment mounted on vibration isolators shall be provided with seismic restraints securely anchored to the building structure capable of resisting horizontal forces of 100% of their weight and/or in accordance with IBC Requirements.

C. All items of fire protection equipment required for life safety including the fire pump and fire protection systems shall be provided with seismic restraints securely anchored to the building

capable of resisting horizontal forces of 100% of their weight and/or in accordance with IBC Requirements.

D. All items of fire protection equipment, except as specified above, and all piping furnished and installed under Division 21 shall be provided with seismic restraints securely anchored to the building capable of resisting horizontal forces of 50% of their weight.

E. Seismic restraint/snubber manufacturer shall be responsible for the structural design of attachment hardware as required to attach seismic restraints/snubbers to both the equipment and supporting structure on vibration isolated equipment, or to directly attach equipment to the building structure for non-isolated equipment.

F. The Contractor shall furnish a complete set of approved shop drawings of all mechanical and electrical equipment which is to be restrained to the seismic restraint manufacturer, from which the selection and design of seismic restraint devices and/or attachment hardware will be completed. The shop drawings furnished shall include, at a minimum, basic equipment layout, length and width dimensions, installed operating weights of the equipment to be restrained and the distribution of weight at the restraint points.

PART 2 - PRODUCTS

See Division 23, Section 23 0548, for applicable requirements.

PART 3 - EXECUTION

See Division 23, Section 23 0548, for applicable requirements.

END OF SECTION 21 0548

SECTION 21 0549 - FIRE SUPPRESSION AND ELECTRICAL INSTALLATION COORDINATION

PART 1 - GENERAL

1.1 REQUIREMENTS

A. Conform with applicable provisions of the General Conditions, Supplemental General Conditions and General Requirements.

1.2 RELATED DIVISIONS AND SECTIONS

A. Section 210500, Common Work Results for Fire Suppression.

B. Division 22 for Plumbing Systems.

C. Division 23 for Facility Management System.

D. Division 26 for Electrical.

E. Division 28 for Fire Alarm System.

1.3 SCOPE

A. It is the intention of this section to summarize the coordination of effort defined in the related sections and divisions of this specification.

B. If there is a conflict between this Section and other Sections and Divisions of this specification, this Section shall be the governing and decisive Section.

C. Make all connections to motors and controls for equipment supplied and/or installed under Division 21 according to Table 1.

PART 2 - PRODUCTS

Not Applicable.

PART 3 - EXECUTION

3.1 INSTALLATION

A. No work shall be performed until the reviewed and marked submittal data have been reissued to the Contractor, unless written permission is obtained from the Architect.

TABLE 1

Item or System	**Note**	**Supplied By (3)**	**Installed By (3)**	**Powered By**	**Control Field Wiring By**
Fused and Non-Fused Disconnects	(1)	Div. 26	Div. 26	Div. 26	N/A
Control Relays & Control Transformers	(1)	Div. 21	Div. 21	Div. 26	Div. 21
Fire Alarm System & Interface w/Fire Suppression Systems		Div. 28	Div. 28	Div. 28	Div. 28
Fire Sprinkler System Control - Supervisory Panels & Devices, Including Tamper Switches & Flow Switches		Div. 21	Div. 21	N/A	Div. 28

TABLE NOTES:

1. Unless specified to be supplied with the equipment

END OF SECTION 21 0549

SECTION 21 1313 - FIRE PROTECTION SYSTEM, AUTOMATIC WET-PIPE SPRINKLER

PART 1 - GENERAL

1.1 REQUIREMENTS

A. Conform with applicable provisions of the General Conditions, Supplement General Conditions and the General Requirements.

B. Division 3 for concrete work.

C. Division 26 for electrical work and building fire alarm system.

D. Architectural Sections of this Specification for required cutting, patching, painting, required in conjunction with the installation of the new sprinkler system within the existing facility.

1.2 RELATED SECTIONS

Section 210500	Common Work Requirements
Section 210503	Trenching and Backfilling for Mechanical Systems
Section 210504	Pipe and Pipe Fittings
Section 210505	Piping Specialties
Section 210523	Valves
Section 210548	Vibration and Seismic Design
Section 230549	Fire Suppression and Electrical Installation Coordination
Section 230900	Facility Management System
Section 233000	Air Tempering System and Equipment
Section 283100	Fire Detection and Alarm

1.3 SCOPE

A. Criteria: This Section covers the requirements for furnishing the design, fabrication, installation, and acceptance testing of a complete automatic wet-pipe sprinkler system.

B. Classification: In accordance with NFPA 13, 101, and 5000 requirements and recommendations.

C. Scope of Work: Provide the design, materials, equipment, fabrication, installation, labor, and supervision necessary to install, disinfect, flush, test, and place into service a complete wet-pipe sprinkler system.

1. Fully sprinkle the facility per NFPA-13 and 5000, the International Building Code, International Fire Code, state and/or local Fire Marshal, and any specific requirements of the Owner's insurance underwriter.

D. Components: Provide all piping, fittings, control valves, check valves, alarm valve (with trim), tamper switches, fire department connection, sprinkler heads, hangers, bracing, test and drain connections, zone flow switches, tamper switches, accessories and incidentals required for a complete installation in accordance with codes and standards referenced in this Section.

E. Protect all fire lines subject to freezing in a manner approved by NFPA. Use anti-freeze loops only as approved by NFPA and the Local Fire Marshal and only with approved backflow protection in accordance with applicable building codes. Electric heat tape will not be permitted.

F. Conform to the applicable provisions of NFPA Standards 13, 101, and 5000 and to the requirements of the International Building Code]. Unless otherwise shown on the Drawings or specified, all materials and equipment used in the installation of the fire protection systems shall be listed in the UL Fire Protection Equipment Directory, and shall be the latest design of the manufacturer. All fire hoses, threads and adapters shall match the standards of the owner.

G. Provide temporary fire protection within all areas of the building under construction as required by the building codes and the Fire Marshal.

H. Provide pendant and upright fire protection for all areas of the building including, but not limited to, concealed combustible spaces, accessible and inaccessible areas, plenums, etc.

1.4 QUALITY ASSURANCE

A. All materials and equipment used in the installation of the fire protection systems shall be UL listed and/or FM approved for intended use, unless stated otherwise in these specifications.

B. Contractor Qualifications: Contractor shall be experienced, licensed and regularly engaged in the design, fabrication, and installation of automatic fire protection sprinkler systems.

C. Certification: Welders and brazers shall be qualified per the ASME Boiler and Pressure Vessel Code, Section IX, Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators.

D. Employ skilled craftspersons and provide proper supervision to ensure the work is erected in a proper manner. Coordinate the work with existing conditions and other disciplines. Visit the premises and thoroughly understand the details of the work and working conditions, and verify all dimensions in the field. If discrepancies are noted which require clarification of the design intent, submit RFIs prior to performing related work. Lay out all work in a manner to avoid all interferences.

E. The drawings show only approximate building outlines and interior construction details as an aid in understanding the scope of work. Follow the drawings as closely as building construction and the work of other trades will permit. Investigate the structural and finish conditions affecting the work and arrange the work accordingly, providing such fittings, traps, valves, and accessories as may be required to meet such conditions. Field verify all dimensions and conditions governing the work.

F. Do not render inoperative any building system without prior approval. Coordinate necessary shutdowns through seven day advanced written notification.

G. Coordinate all fire protection piping and sprinklers with the ceiling or roof materials, lighting, ductwork, conduits, piping, suspended equipment, structural, and other building obstructions to provide an installation in compliance with the appropriate building codes, and NFPA Standards.

1.5 EXISTING CONDITIONS

A. Examine existing conditions and related work required for the design and installation of the fire suppression system.

B. Perform all field tests and inspections as may be necessary to determine water flow, fire protection and pressure characteristics (static and residual pressure and residual flow) necessary for the design and installation of the fire protection system. Contact the water utility to determine whether they anticipate any degradation in the available water source. Prior to starting design, procurement, and installation, submit to the Owner and Engineer a written report documenting the results of this discussion with the water utility.

1.6 OPERATION PRIOR TO ACCEPTANCE

A. The Owner may wish to place portions of the fire suppression systems in service prior to substantial completion. In this case, a written agreement will be prepared establishing warranty and other responsibilities to the satisfaction of both parties.

1.7 SUBMITTALS

A. See Division 1 and Section 210500 for general submittal requirements.

B. Within 45 days after the contract is awarded, provide submittal data for the complete fire suppression system for review.

1. Submit sprinkler system design drawings and hydraulic calculations to the Fire Marshal, the Building Department AHJ, and the Owner's Insurer for review, comment, and approval.

    a. Drawings must be prepared by either a minimum Level 3 NICET Certified Technician, or a professional engineer.
    b. Drawings must be stamped by a professional engineer registered in fire protection.

2. Upon receipt of stamped and approved system design drawings and hydraulic calculations from the Fire Marshal, the Building Department AHJ, and the Owner's Insurer, submit required sets of complete submittal data to the Architect as per spec Section 210500.

C. Submit complete data describing all equipment and materials to be furnished including performance, quality, dimensions, and certifications of approving agencies. Include plans showing location and arrangement of water supply connection, control valve, fire department connections, alarm bells, tamper switches, on-site fire main routing, on-site fire hydrants and other equipment to be used; and including head layouts coordinated with lighting, plumbing and air conditioning systems. Submittals shall include the following:

1. Shop drawings.
2. Certifications (after installation and tests are completed).
3. Equipment list.
4. Material list.
5. Installation instructions.
6. Maintenance instructions.
7. Operating instructions.
8. Samples, colors.
9. Welder's certification.
10. Catalog data (appropriate unit identified on cut).
11. Recommended spare parts lists.
12. Verifiable calculations.
13. Nameplate data.

D. Complete Package: Submit fire suppression work as a complete package to permit analysis of the system(s) and its components. Partial submittals will not be accepted.

E. Hydraulic Calculations: Submit computerized hydraulic calculations. Maintain a minimum of 10 percent, but not less than a 5 psi buffer below the final water supply curve after accounting for required hose streams, pipe friction elevation differences, etc. Hydraulic design sprinkler system shall be in accordance with the following:

1. Sprinkler System Occupancy Hazard Classifications:

    a. Office and Public Areas: Light Hazard
    b. Storage Areas: Ordinary Hazard Group 2
    c. Equipment Rooms: Ordinary Hazard Group 1
    d. Service Areas: Ordinary Hazard Group 1

2. Minimum Density Requirements for Automatic Sprinkler Hydraulic Design:

    a. Light Hazard Occupancy: 0.10 gpm over 1500 sf area.
    b. Ordinary Hazard, Group 1 Occupancy: 0.15 gpm over 1500 sf area.
    c. Ordinary Hazard, Group 2 Occupancy: 0.20 gpm over 1500 sf area.
    d. Special Occupancy Hazard: As determined by authority having jurisdiction.

F. Shop Drawings: Minimum 1/8" = 1'0" for plans, and 1/4" = 1'0" for details, with minimum 3/16 inch lettering. Show all piping, sprinklers, hangers, flexible couplings, roof construction, electro-mechanical devices, and occupancy of each area, including ceiling and roof heights as required by NFPA 13 and 5000. Show hydraulic reference points and remote areas.

G. Record Drawings: Provide mylar reproducible record drawings and AutoCAD 2008 files showing all work under this contract. Indicate any special systems or devices such as dry pendant heads, antifreeze loops, inspector's test connections, etc. Submit record drawings prior to requesting final payment.

1.8 PRODUCT HANDLING

A. Materials and Equipment: Protect materials and equipment from damage during shipping, storage, and installation.

B. Materials and Equipment Installation: Ensure materials and equipment are free of moisture, scale, corrosion, dirt, and other foreign materials prior to installation.

C. Plugs and Cover Plates: Protect flanged openings with gasketed metal cover plates to prevent damage during shipment. Cap or plug all drains, vents, and small piping or gauge connections.

D. Sprinkler Head Protection: Remove frangible bulb protectors after sprinkler heads are installed. Protect sprinkler heads with factory-supplied caps and covers until ceiling installation is complete.

1.9 ENVIRONMENTAL CONDITIONS

A. The sprinkler system and system components shall be designed to operate at an elevation of 7000 feet above sea level and in freezing temperatures when exposed to outside conditions.

1.10 ALARM FACILITIES

A. Provide water flow switches and tamper switches. Integrate these and other required sprinkler system alarm devices into the building fire alarm system provided under Division 26. Coordinate with Division 26, Fire Detection and Alarm, regarding the requirements and location of items provided under this section which must be integrated with the fire alarm system.

B. Provide tamper switches on all required valves and devices used in conjunction with the building fire protection system.

1.11 ELECTRICAL CONNECTIONS

A. The fire alarm system will monitor waterflow indicators, tamper switches, etc., provided under this Section.

PART 2 - PRODUCTS

2.1 GENERAL

A. All material and equipment furnished shall be in accordance with the following requirements

and NFPA 13 and 5000. All fire protection materials and equipment shall be new and unused, shall be free of defects and specifically designed for the use intended, shall conform to the requirements of NFPA 13 and 5000, and shall be UL listed and FM approved, unless otherwise noted in the Specification.

B. Any deviation to the above requirements shall be submitted to the Architect for approval. The deviation submittal shall be clearly identified as a "deviation."

2.2 PIPING MATERIAL

A. Material Requirement: Automatic sprinkler piping shall be in accordance with this Section and NFPA 13 and 5000, respectively.

B. Underground piping, to a point 5'0" from the building perimeter, shall be as specified for underground water services of this Specification.

C. Underground piping within the building and to a point 5'0" from the building perimeter shall be AWWA Class 200 ductile iron water main pipe and fittings with mechanical joints. Interior of pipe and fittings shall be cement lined. Exterior of pipe and fittings shall be bituminous coating or equivalent. All changes in direction shall be adequately blocked or strapped to prevent separation of joints.

D. Interior building piping systems shall be black steel pipe ASTM A120, or A53 Grade A or B, ERWQ or BW, Standard wall, Schedule 40. UL and FM approved thin wall (Schedule 10, minimum) ASTM A135 or A795 piping may be utilized for sprinkler system as allowed by NFPA and the Fire Marshal. Piping installed outside or exposed to outdoor ambient conditions shall be galvanized.

2.3 FITTINGS

A. Changes of direction shall be accomplished by the use of fittings suitable for use in sprinkler systems as defined in Article 3-13 of NFPA 13 and 5000. Fittings installed outside or exposed to outdoor ambient conditions shall be galvanized.

B. Fittings and specials for ductile iron pipe shall be Class 250 to match pipe, conforming to AWWA C110, mechanical flange joint type. All ductile iron fittings shall be cement lined.

C. Fittings for steel pipe shall be cast iron screwed, welded fittings, or UL and FM approved mechanical pipe couplings and fittings as manufactured by Victaulic or equivalent in accordance with requirements specified in Section 210504.

2.4 JOINTS

A. Joints shall be provided in accordance with Section 21 0504, Pipe and Pipe Fittings, and the manufacturer's instructions. Threaded joints for thin-wall (Schedule 10) piping shall be provided in strict accordance with NFPA requirements, UL and FM approvals for threadable thin-wall piping.

2.5 UNIONS AND FLANGES

A. Unions and flanges shall be provided in accordance with Section 210504, Pipe and Pipe Fittings. Gaskets shall be as recommended by the manufacturer and suitable for service on which used.

2.6 HANGERS AND SUPPORTS

A. See Section 21 0504, Pipe and Pipe Fittings, for general requirements associated with equipment piping systems hangers and supports. Seismic supports for fire protection system shall be provided in accordance with NFPA requirements.

B. All fire protection piping shall be rigidly supported from the building structure by means of adjustable ring type hangers. Piping hangers shall be spaced as specified in NFPA 13, Chapter 2 and 5000. Piping system shall be installed in an approved manner and shall not overload the structure. The Contractor shall provide additional hangers and steel support members as may be required to distribute the piping weight over several structural members where required or directed. Fire protection piping system shall be supported independent and shall not be attached or supported from hangers, trapezes, or supports provided for other piping systems or equipment.

2.7 VALVES

A. See Section 210523, Valves, for general valve requirements. All valves for fire hose fire department connections shall have threads and adapters to match the standard of the local Fire Department. All valves shall be UL listed and FM approved. Valve sizes shall be determined by the approved hydraulic calculations. Outside screw and yoke valves shall be indicated on the approved hydraulic calculations. Tamper switches shall be provided on all valves controlling fire protection system operation, as required by NFPA**.** Valves shall be rated for working pressure not less than the maximum pressure to be developed at that point in the system under any operating condition.

B. Gate valves 2" and under, shall be bronze body and trim, outside screw and yoke, wedge disc, screwed connections, 400 psi W.O.G. maximum working pressure.

C. Gate valves, 2-1/2" and larger, shall be Class 125 or Class 250, as required, with flanged ends, outside screw and yoke, bronze seals, wedge disc, iron body.

D. Drain valves shall be globe valve or angle body globe valve, with screwed ends, bronze body and trim, 200 psig W.O.G. maximum working pressure. Furnish and install as required by NFPA No. 13 and 5000.

E. Swing check valves 2" and smaller shall be y-pattern, horizontal swing bronze body, bronze trim, 200 psig W.O.G. screwed connections.

F. Swing check valves 2-1/2" and larger, shall be iron body, clearway swing check, Class 125 or Class 250 as required with flanged or grooved connections.

G. Automatic Ball Drips: Automatic ball drips shall be 1/2" or 3/4" as required normally open, which close when the flow of water through the valve exceeds 4 to 10 gpm, 175 psig working pressure, Underwriters' Laboratories, Inc., or Factory Mutual approved, Standard Fire West No. 5248 or equivalent.

H. Post indicator fire main control valve shall be vertical post type for underground valve control] provided as shown on the Drawings, Underwriters' Laboratories, and Factory Mutual approved pattern with approved gate valve and tamper switch. Vertical post indicator shall be Mueller Co. Model A-20804 with Mueller AWWA non-rising stem gate valve, A-2050 Series or equivalent.

2.8 ALARM CHECK VALVES

A. Furnish complete wet-pipe sprinkler system alarm check valve assembly with all accessories required for system operation, supervision and alarm. Valves shall be UL listed and FM approved, designed to automatically activate electrically and/or hydraulically operated alarms and shall be furnished in the required size and arrangement with either flanged or grooved connections.

B. Furnish retard chamber, pressure gauges, valves, and trim including water motor gong and alarm switch with both normally open and normally closed electrical contacts.

C. Alarm check valve assembly shall be as manufactured by Tyco Fire Products or equivalent.

2.9 PRESSURE GAUGES

A. Pressure gauges shall be designed for use with water. Gauges shall be of the Bourdon type having an enclosed phosphor-bronze type. The moving parts shall be brass or stainless steel except the hairspring, which is phosphor-bronze. The case and ring shall be brass or stainless steel, and the ring shall be either threaded or pressed over the case. Gauges shall be 4-1/2 inch size with dial marking subdivisions no finer than one percent of the maximum scale reading, and shall be accurate to two percent or less. The gauge scale, when possible, shall be at least twice the maximum working pressure. All gauges shall be FM approved and UL listed.

2.10 TAMPER SWITCHES

A. All valves which control water to automatic sprinkler heads shall be equipped with supervisory switches having one normally open contact and one normally closed contact. Valve supervisory switches shall be single pole double throw switching contacts, and shall be housed in a gasketed weathertight enclosure. The supervisory device supplied shall be specifically designed to mount on, and operate reliably with, the type of control valve being monitored. All valve position switches shall be adjusted to transmit a supervisory signal within two revolutions of the valve operating hand wheel or crank (away from its full open position).

2.11 FLOW SWITCHES

A. Water flow switches shall be field adjustable vane-type with pneumatic retard and 175 psi working pressure. Units shall be single pole double throw, normally open, suitable for 24-volt, DC service or as otherwise required to interface with Building Fire Alarm system. Water flow switches shall be adjusted so that the device will transmit a water flow alarm within 90 seconds of opening the inspector's test valve on the sprinkler system. The flow switch shall be furnished and installed under this Section of Specifications and electrically connected under Division 26. Flow switches when required for zoning shall be piped and installed so that only one flow switch actuates when an alarm in that zone is present.

2.12 SPRINKLER HEADS

A. Sprinkler heads and accessories shall be UL listed or FM approved for the intended service, quick response automatic closed type, 165 deg F rated with 1/2" orifice, except as may be otherwise required for the specific application, and subject to NFPA 13, 101, and 5000 requirements and recommendations. Sprinkler heads with higher temperature ratings shall be installed in electrical and mechanical equipment areas, in areas where occupancy may generate high ambient temperatures, where installed in the vicinity of heat producing equipment, attic spaces, where exposed to the direct rays of the sun and beneath skylights and windows, and at other such locations as required by NFPA 13 and 5000.

B. Sprinkler heads installed in unfinished areas without suspended ceilings shall be upright bronze or brass. Sidewall type heads may be used in areas with low headroom as approved by the Fire Marshal.

C. Sprinkler heads in areas with suspended ceilings including toilet facilities, storage rooms, and similar building spaces shall be chrome plated bronze pendant type or white painted finish as selected by the Architect unless otherwise noted. Sidewall heads in finished areas shall be horizontal, chrome plated bronze.

D. For all building areas, except as indicated above, furnish concealed sprinkler heads consisting of sprinkler head installed within brass enclosure assembly with cover plate with white finish or satin chrome, as approved by the Architect.

E. Supply spare heads of each type as required by NFPA 13 and 5000. Provide a metal cabinet with a sprinkler head wrench for each type head.

F. Provide sprinkler head guards where required by NFPA 13 and 5000 nd where appropriate.

G. Approved Manufacturers: Tyco Fire Products, Viking, or equivalent.

2.13 SYSTEM ACCESSORIES

A. Fire Department Connections: Fire department connections shall be of the type and style shown on the civil drawings, cast brass body, double clappers, plugs, and attached chains. All exposed surfaces, caps and chains shall be chrome plated. Identification shall be by raised letters on the individual devices, or shall consist of attached escutcheon plates of the same material. Label shall read "AUTO SPKR". The dimension from grade level to the center of the 2-1/2-inch inlets

shall be 34 inches (plus or minus 2 inches). Make the fire department connection above the inlet to the alarm valve.

B. Plaques: Main riser plaques shall be 7 inches by 10 inches with four mounting holes (one in each corner), and shall have white lettering on red porcelain with white blank for the "design data." Plaque shall meet all requirements of NFPA 13, Chapter 7 and 5000.

C. Strainers: Strainers, where required, shall be "Y" type with cast iron body, 30 mesh monel screen, flanged ends, 1-1/2-inch blow down connection discharging to outside, and shall be rated at 175 psi working pressure for cold water service.

D. Splash Blocks: Splash blocks shall be concrete, 12 inches by 24 inches by 4 inches thick. A commercially available splash block may be provided as a suitable alternate.

2.14 ACCESS DOORS

A. All concealed valves, controls, etc., shall be provided with access doors as specified under Section 210500, Common Work Requirements.

PART 3 - EXECUTION

3.1 FIELD CONDITIONS

A. Prior to installation the Contractor shall carefully inspect the installed work of all other trades and verify that all such work is complete to the point where the installation of the sprinkler system may properly commence.

B. The Contractor shall verify that the entire sprinkler system may be installed in accordance with all referenced codes, regulations, standards, and the original approved design.

3.2 INSTALLATION

A. General

1. The complete fire protection system shall be installed in accordance with NFPA 13 and 5000. The project drawings provide general information concerning the system arrangements, equipment, material, sizes, and other requirements and shall be utilized by the Contractor for this purpose. However, the Contractor shall have complete responsibility for the system design and installation in accordance with the requirements of this Specification.
2. All pipe, fittings, valves, equipment, and accessories shall be visually examined to ensure that they are clean and free of all burrs, cracks, and other imperfections before being installed. During the progress of construction, open ends of pipes, fittings, and valves shall be properly protected at all times to prevent admission of foreign matter.

B. Piping

1. Installation of fire sprinkler piping system shall be in accordance with all applicable requirements contained in Section 210500 – Common Work Requirements, Section 210504 – Pipe and Pipe Fittings, and Section 210505 – Piping Specialties.
2. All fire sprinkler piping shall be so arranged and include such devices to separate the system into individual and distinct alarm zones as shown on the contract drawings and as required by NFPA recommendation and the Fire Marshal. A minimum of one zone per floor will be required unless shown otherwise on the contract drawings.
3. Sprinkler piping shall be marked and identified in accordance with Section 210500, Common Work Requirements.
4. The arrangements of all piping systems shall conform to Architectural requirements and field conditions, and shall be run straight and direct, forming right angles or parallel lines with building walls and other pipes, and shall be neatly spaced. Offsets will be provided where required. Standard fittings shall be used for offsets. All risers shall be erected plumb and true, and shall be parallel with the walls and other pipes and shall be neatly spaced. All work shall be coordinated with all Sections of Division 21, 22, and 23, and Division 26, "Electrical," in order to avoid interference of pipe and unnecessary cutting of floors and walls.
5. No pipes or other apparatus shall be installed so as to interfere in any way with the full swing of the building doors, access doors, equipment access, etc.
6. Inspector's test and test pipes shall be piped from the end of the most remote branch line of the automatic sprinkler system to the exterior of the building.
7. When trapped capacity is more than five gallons, provide auxiliary drains consisting of a one-inch valve, nipple, and cap. When trapped capacity is less than five gallons, auxiliary drain shall be one-inch nipple and cap or plug.
8. Provide main drain valves at system alarm valves and extend piping to discharge at exterior at a location approved by the Architect. All pipe and fittings downstream of drain valve shall be galvanized.
9. All concrete penetrations shall be sleeved, then grouted and sealed with fire-resistive material that shall be securely held in place.

C. Welding

1. No field welding of sprinkler piping shall be permitted.
2. Headers, risers, feed, crossmains, and branch lines may be shop welded using approved welding fittings. Welding and brazing shall conform to American National Standard Institute for Power Piping, ANSI B 31.10, with Addenda ANSI B 31.10a and ANSI B 31.10b. Welding and torch cutting shall not be permitted as a means of installing or repairing sprinkler systems.
3. Provide a blind flange at each end of welded headers.
4. Welders and brazers shall be certified for welding and/or brazing in accordance with the requirements of ASME Boiler and Pressure Vessel Code, Section IX, Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators. Welders must be certified for work they perform, and certificates shall be checked before the work commences.

D. Alarm Check Valve: Alarm check valves shall be installed with the valve and trim set plumb, and shall be unobstructed. Clear distances shall be as listed below:

Rear:	12 inches
Sides:	18 inches
Front:	24 inches

E. Control Valves: OS&Y fire protection control valves shall be installed so that the stem can be readily seen.

F. Sprinklers and Accessories

1. Sprinkler heads in finished areas are to be installed on a true axis line in both directions with a maximum deviation from the axis line of 1/2" plus or minus. Heads exceeding this shall be removed and reinstalled. Sprinkler heads shall be located in the center of the ceiling tiles, unless otherwise directed.
2. Provide chrome-plated escutcheons where exposed piping passes through finished floors, walls, partitions, and ceilings. Secure plates to pipe with setscrews or spring clips.
3. Provide spare sprinkler head cabinets per NFPA 13 and 5000.

3.3 EQUIPMENT INSTALLATION

A. Installation of all devices or equipment not specifically covered by these Specifications shall be in accordance with manufacturer's instructions.

3.4 TEMPORARY FIRE PROTECTION

A. During the construction of the building and until the permanent fire extinguishing system has been installed and is in service, temporary fire protection shall be provided as required by the Fire Marshal.

3.5 INSPECTION AND TESTING

A. The complete fire protection systems and piping acceptance testing shall be performed by the Contractor and witnessed. Advance notice shall be given by the Contractor prior to any tests.

B. Inspection Prior to Testing: The Contractor shall submit notification upon completion of the installation of all materials and equipment.

C. Water Piping Disinfection: The Contractor shall furnish all hoses, connections, and equipment to flush piping clear and free of debris and to rinse piping of disinfectant. Flushing per NFPA Figure A-10.10-2.1 and 5000. All fittings and connections required for water piping, flushing, and disinfection shall be furnished by the Contractor.

D. Chlorine Application: Water from the existing distribution system, or other approved supply source, shall be made to flow at a constant measured rate into the newly installed piping. The water shall receive a minimum chlorine dosage of 300 mg/1. The Contractor shall not allow any anti-freeze glycerine to come in contact with the chlorine. The chlorine shall be applied

continuously and for a sufficient period to develop a solid column of chlorinated water that will expose all interior surfaces to a concentration of at least 30 mg/1 for at least three hours. The application shall be checked at a tap near the downstream end of the line by chlorine residual measure. The chlorine residual measurement test shall be performed by the Contractor and the results submitted.

E. Final Flushing: After the applicable retention period, the heavily chlorinated water in the entire system shall be flushed until the chlorine concentration is not higher than that of the source.

F. Pressure Testing: Pressure tests shall consist of at least flushing, hydrostatic testing, and operation testing and shall be performed in strict accordance with the requirements of NFPA 13 and 5000. For all above-grade piping, test pressure of 200 psi shall be held for a continuous period of two hours with no drop in pressure. Each complete system (main riser with all associated piping and alarms) shall be tested and accepted as a complete unit. System pressure test shall be against a blank test flange and not against a valve seat. Tests may be conducted by the Contractor on small sections of each complete unit for the benefit of the Contractor. An air pressure test may be provided in accordance with NFPA 13 and 5000. An air pressure of 40 psig shall be pumped up, allowed to stand 24 hours, and all leaks which allow a loss of pressure over 1.5 psig during the 24 hours shall be fixed.

G. Unsatisfactory Tests: If any of the above tests fail to produce satisfactory results, tests shall be repeated at no additional cost to the Owner until satisfactory results have been obtained.

3.6 CERTIFICATION

A. The Contractor shall certify that the system has been installed in accordance with all referenced codes and standards. The Contractor shall submit this certification upon completion of tests.

3.7 MAINTENANCE AND OPERATING INSTRUCTIONS

A. System description, system theory of operation, and system final inspection and acceptance documents of the completed system shall be submitted in a bound book (four copies). The maintenance manuals and instructions shall include a brief description of the type of system installed, routine-type work defined by step-by-step instructions that should be performed to ensure long life and proper operations, and the recommended frequency of performance. The instructions shall also include possible trouble spots with diagnosis and suggested correction of each. The theory of operation brochures shall describe the function of each component or subassembly. A copy of the completed Contractor's Materials and Test Certificate (reference NFPA-13, Chapter 24 and 5000) shall be included to document the final inspection, operating test, acceptance and placement of system in service.

END OF SECTION 21 1313

SECTION 22 0500 - COMMON WORK REQUIREMENTS FOR PLUMBING

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. See General Conditions and Supplemental General Conditions.

B. The requirements listed under General Conditions and Supplemental General Conditions and the General Requirements are applicable to this section and all subsequent Sections of Division 22 and form a part of the contract.

C. Division 21 for Fire Suppression Systems.

D. Division 23 for Heating, Ventilating & Air Conditioning (HVAC) Systems.

E. Division 26 for Electrical Systems.

F. Division 31 for Trenching, Backfilling and Compaction requirements.

G. Division 33 for requirements of site utility systems including sanitary sewer storm sewer domestic water distribution system and natural gas service.

H. All electrical work, regardless of voltage which is provided under Division 22 shall comply with the requirements of the National Electric Code (NEC) and Division 26.

1.2 PLUMBING DIVISION INDEX

Section 22 0500	Common Work Requirements for Plumbing
Section 22 0503	Trenching and Backfilling for Plumbing
Section 22 0504	Pipe and Pipe Fittings for Plumbing
Section 22 0505	Piping Specialties for Plumbing
Section 22 0523	Valves for Plumbing
Section 22 0549	Plumbing and Electrical Installation Coordination
Section 22 0700	Plumbing Insulation
Section 22 1100	Domestic Water Piping
Section 22 1123	Facility Natural Gas System
Section 22 1316	Sanitary Waste and Vent Piping
Section 22 1400	Facility Roof Drainage
Section 22 4000	Plumbing Fixtures and Trim
Section 22 6801	Onsite Natural Gas

1.3 CODES AND PERMITS

A. The plumbing work shall be performed in strict accordance with the applicable provisions of the International Building Code, 2015 Edition; the Uniform Plumbing Code, 2012 Edition; the Uniform Mechanical Code, 2012 Edition and the International Fire Code, 2015 Edition as adopted and the National Fire Protection Association (NFPA Regulations), current adopted edition, regarding plumbing systems and electrical systems. All materials and labor necessary to comply with rules, regulations and ordinances shall be provided. Where the drawings and/or specifications indicate materials or construction in excess of code requirements, the drawings and/or specifications shall govern. The Contractor shall hold and save the Architect, Engineer and Owner's Representative free and harmless from liability of any nature or kind arising from his failure to comply with codes and ordinances.

B. Permits necessary for performance of the work shall be secured and paid for by the Contractor. See Division 33 for all requirements associated with utility permits and fees, connections, extensions, meter pits, and meter sets.

C. The following lists some applicable codes and standards that shall be followed.

Applicable county and state mechanical, electrical, gas, plumbing, health and sanitary codes, laws and ordinances.

National Electrical Manufacturer's Association Standards

National Electrical Code

Underwriters Laboratories, Inc. Standards

American National Standards Institute

American Society for Testing Materials Standards

Standards and requirements of local utility companies.

National Fire Protection Association Standards

American Society of Mechanical Engineers Boiler and Pressure Vessel Codes

Occupational Safety and Health Act

Commercial and Industrial Insulation Standards (MICA)

American Gas Association

The American Society of Sanitary Engineering

National Sanitation Foundation

1.4 RECORD DRAWINGS

A. See Division 1, for requirements associated with Project Record Drawings.

1.5 QUALIFICATIONS

A. All mechanics shall be skilled in their respective trade.

B. All welders shall be certified in accordance with the ASME Boiler Test Code, Section IX, latest issue.

1.6 QUALIFICATION PROCEDURES

A. The storage, handling, and transportation of all refrigerants, oils, lubricants, etc. shall be accomplished in strict compliance with all State, local, and Federal Regulations including all requirements set forth by the Environmental Protection Agency (EPA) for the safe handling of regulated refrigerants and materials. The Contractor shall utilize qualified and/or certified personnel and equipment as prescribed by these requirements.

1.7 HAZARDOUS CONDITIONS

A. Protruding metal (bolts, steel angles, etc.) potentially hazardous to maintenance and operation personnel, shall be cut back and/or protected to reduce the risk of injury.

1.8 HAZARD SIGNS

A. Equipment rooms, fan plenums, and similar areas containing moving or rotating parts, or other potentially hazardous environments shall include signs on all doors entering such spaces that shall read similar to the following: "Hazardous Area - Authorized Personnel Only."

B. Confined Spaces: Areas designated by OSHA Standard 1910.146 as a confined space shall be marked with a sign that reads "Confined Space - Entry by authorized personnel only, by permit."

1. "Confined Space" means a space that:

a. Is large enough and so configured that an employee can bodily enter and perform assigned work; and
b. Has limited or restricted means for entry or exit (for example, tanks, vessels, storage bins, hoppers, vaults, and pits are spaces that may have limited means of entry); and
c. Is not designed for continuous employee occupancy.

C. The Contractor shall survey the final premises to determine where any such potentially hazardous areas exist. If the Contractor feels that hazards exist which cannot be suitably provided for through the above typical methods, he shall forward in writing his concerns, and request for a decision concerning the referenced hazard, prior to the final inspection of the facilities.

1.9 SUBMITTALS

A. The Contractor shall submit submittal brochures of all equipment, fixtures and materials to be furnished under Division 22, including but not limited to the following:

1. Piping materials, valves, insulation materials and installation methods, vibration isolation devices, pipe penetration installation methods and products for fire rated assemblies, and all plumbing equipment listed on equipment schedules, and in related construction documents.
2. Materials, certification, shop drawings, and other information as specified in the individual Division 22 Specification Sections within this Specification.

B. Unauthorized Substitutions: If substitute materials, equipment or systems are installed without prior review or are installed in a manner which is not in conformance with the requirement of this Specification and for which the Contractor has not received a written review, removal of all the unauthorized materials and installation of those indicated or specified shall be provided at no change in contract amount.

C. All equipment shall be installed in accordance with the manufacturer's recommendations. Provide all accessories and components for optimum operation as recommended by the manufacturer.

D. Expense: All costs for the preparation, correction, delivery, and return of the submittals shall be borne by the Contractor.

E. See Division 1 for additional submission requirements.

F. Complete data must be furnished showing performance, quality and dimensions. No equipment or materials shall be purchased prior to receiving written notification that submittals have been reviewed and marked either "NO EXCEPTIONS TAKEN" or "EXCEPTIONS AS NOTED." Submittals returned marked "EXCEPTIONS AS NOTED" do not require resubmittal provided that the Contractor agrees to comply with all exceptions noted in the submittal, and so states in a letter.

G. Review of Submittals: Submittals will be reviewed with reasonable promptness, but only for conformance with the design concept of the Project and for conformance with the information indicated on the Drawings and stated in the Specifications. Review of a separate item as such will not indicate review of the assembly in which the item functions. Review of submittals shall not relieve the Contractor of responsibility for any deviation from the requirements of the Contract Documents, nor for errors or omissions in the submittals; or for the accuracy of dimensions and quantities, the adequacy of connections, and the proper and acceptable fitting, execution, functioning and completion of the work. Review shall not relieve the Contractor of responsibility for the equipment fitting within the allotted space shown on the drawings with all clearances required for equipment operation, service and maintenance including minimum clearances required by applicable codes, manufacturer's installation instructions and as necessary for proper clearance in front of all electrical panels as defined by the National Electric Code (NEC). Any relocation of plumbing and/or electrical equipment, materials and systems required to comply with minimum clearances shall be provided by the Contractor without additional cost under the Contract.

H. Shop drawings will be returned unchecked unless the following information is included: cover sheet shall be provided for each submittal of equipment, products and material proposed for use on the project. A common cover sheet for similar equipment (example: all air handling units or all fire protection products) is acceptable. The cover sheet shall list equipment by symbol number; reference all pertinent data in the Specifications or on the drawings; provide size and characteristics of the equipment, name of the project and a space large enough to accept a review stamp. The data submitted shall reflect the actual equipment performance under the specified conditions and shall not be a copy of the scheduled data on the drawings. Cover sheet shall clearly identify any deviations from the specifications for submitted equipment, products, and materials.

I. Use of substitutions reviewed and checked by the Engineer does not relieve the Contractor from compliance with the Contract Documents. Contractor shall bear all extra expense resulting from the use of any substitutions where substitutions affect adjoining or related work required in this Division or other Divisions of this Specification.

J. If Contractor substitutes equipment for that drawn to scale on the drawings, he shall prepare a 1/4" = 1'-0" installation drawing for each equipment room where a substitution is made, using dimensions of substituted equipment, and including piping, and electrical equipment requirements, to verify that equipment will fit space with adequate clearances for maintenance. This 1/4" = 1'-0" fabrication drawing shall be submitted for review with the shop drawing submittals of the substitution. Failure to comply with this requirement will result in the shop drawings being returned unchecked.

K. Refer to specification Section 01 8113 Part 1.5 for LEED product submittal requirements.

1.10 COORDINATION DRAWINGS

A. The Contractor shall, in advance of the work, prepare coordination drawings for:

1. Equipment rooms, and other spaces housing plumbing and equipment, etc.
2. Piping and chases.
3. Complete plumbing piping systems located within the building.
4. Layout of all plumbing equipment.
5. Corridors

B. Show the location of piping openings through the building floors, walls and roofs coordinated with Architectural and Structural, as well as the location and elevations of building fire suppression equipment and systems, including piping, coordinated with HVAC plumbing, fire suppression and electrical systems. Coordination drawings, including plans, elevations and sections, as appropriate, shall clearly show the manner in which the plumbing systems fit into the available space and coordinates with HVAC and plumbing equipment, ductwork, piping, sprinkler heads, and electrical equipment, including conduits, light fixtures, motor control centers, transformers, panels, variable frequency drives, etc. Drawings shall demonstrate required code clearances for mechanical and electrical equipments, control panels, etc., and proper operation, maintenance and replacement of plumbing devices and equipment. Coordination drawings shall be of appropriate scale to satisfy the previously stated purposes, but not smaller than 1/8 inch scale for floor plans and 1/4 scale of equipment rooms and chase areas. Drawings may be composite or may be separate but fully coordinated drawings of the same scale. Every subcontractor must sign-off on coordination

drawings prepared by each craft. Failure to sign-off will indicate that subcontractor is proceeding at his own risk. Any cost required to relocate systems to comply with required clearance and equipment installation requirements shall be provided by the Contractor without additional cost under the contract.

C. Seven (7) complete sets of coordination drawings shall be submitted prior to the scheduled start of the work in the area illustrated by the drawings, for the purpose of showing the Contractor's planned method of installation. The objectives of such drawings are to promote carefully planned work sequence and proper coordination, in order to assure the expeditious solutions of problems, and the installation of lines and equipment as contemplated by the contract documents while avoiding or minimizing additional costs to the Contractor and to the Owner.

D. In the event the Contractor, in coordinating the various installations and in planning the method of installation, finds a conflict in location or elevation of any of the plumbing systems, with the structural items or with other construction items, such conflicts shall immediately be documented and submitted for clarification. In doing so, the Contractor shall explain the proposed method of solving the problem, or shall request instructions as to how to proceed if adjustments beyond those of usual trades coordination are necessary.

E. Installation of plumbing work shall not proceed prior to the submission and completion of the review of the coordination drawings, and any conflicts which are disclosed by the coordination drawings. It is the responsibility of the Contractor to submit the required drawings in a timely manner consistent with the requirements for completing the work covered by this contract within the prescribed contract time.

1.11 USE OF CADD FILES

A. Under certain conditions, the Contractor will be permitted the use of the Engineer's CADD files for documentation of as-builts, submittals, or coordination drawings.

B. The Engineer shall be compensated for the time required to format the CADD files for delivery to the Contractor. Such work may include removal of title blocks, professional seals, calculations, proprietary information, etc.

C. The Contractor shall complete the enclosed License, Indemnity and Warranty Agreement, complete with contractor's name, address, and Contractor's Representative signature prior to request for CADD file usage.

1.12 PRIOR APPROVAL

A. Equipment manufacturers and service providers are listed within the specifications for the work specified in this division. For the items listed below, the specified manufacturers and providers are the only ones presently approved, and may be the only ones allowed:

1. Plumbing Fixtures and Trim.
2. Domestic Gas Water Heater.
3. Domestic Hot Water Recirculation Pumps.

B. Manufacturers and service providers who are not listed in these specs, and who offer equivalent or superior products or services, are invited to submit for approval prior to bid (prior approval). Submit two copies. Requests for prior approval must:

1. Include the substitution request form at the end of this spec section.
2. Include technical data sufficient for the Engineer to generally assess appropriateness for this project.
3. Be submitted minimum ten days prior to the bid date in effect at the time of submission.
4. Comply with any additional requirements per specification Division 1.

C. Any additional prior approved alternate manufacturers and service providers will be published in an addendum prior to bid. Prior approval indicates that based on the information submitted it appears to the Engineer that the alternate might be capable of meeting the specifications and the design intent, and might be appropriate for the project. But prior approval does not guarantee this. Prior approved products and service providers must still go through the submittal process after award, and must still comply with the design intent and all specification requirements.

D. Please do not request prior approval for products and service providers that are not listed above. Instead, for those items alternate manufacturers and alternate service providers may be submitted after bid in accordance with the submittal process, provided they meet or exceed the specifications and the indicated design intent.

1.13 GUARANTEE-WARRANTY

A. See Division 1 for additional warranty requirements.

B. The following guarantee is a part of the specifications and shall be binding on the Contractor:

> "The Contractor guarantees that this installation is free from defects. He agrees to replace or repair any part of the installation which may fail within a period of one year after date established below, provided that such failure is due to defects in the materials or workmanship or to failure to follow the specifications and drawings. Warranty of the Contractor-furnished equipment or systems shall begin on the date the system or equipment is placed in operation for beneficial use of the Owner or occupancy by the Owner, whichever occurs first; such date will be determined in writing, by means of issuing a 'Certificate of Substantial Completion', AIA Form G704", or equivalent.

C. The extent of guarantees or warranties by Equipment and/or Materials Manufacturers shall not diminish the requirements of the Contractor's guarantee-warranty to the Owner.

D. All items of plumbing equipment shall be provided with a full one (1) year parts and labor warranty, from the date of acceptance by the Owner.

PART 2 - PRODUCTS

2.1 QUALITY OF MATERIALS

A. All equipment and materials shall be new, and shall be the standard product of manufacturers regularly engaged in the production of plumbing equipment and shall be the manufacturer's latest design. Specific equipment, shown in schedules on drawings and specified herein, is to set forth a standard of quality and operation.

B. Hazardous or Environmentally Damaging Materials: Products shall not contain asbestos, mercury, PCS, or other materials harmful to people or the environment.

2.2 ALTITUDE RATINGS

A. Unless otherwise noted, all specified equipment capacities are for an altitude of 7000 feet above sea level and adjustments to manufacturer's ratings must be made accordingly.

2.3 LEED

A. Provide submittals as required by Section 01 8113 Supplemental Table(s):
   1. Submittal Requirements for LEED v4 Materials and Resources Credits.
   2. Submittal Requirements for LEED v4 Environmental Quality Credits.

2.4 ELECTRICAL SERVICES - MOTORS

A. Each motor, unless otherwise specified of 3/4 HP and greater, shall be designed for operation with 3 phase, 60 Hz, 208 or 480 volt electrical service. Unless otherwise specified, motors of 1/2 hp and less shall be designed for operation with single phase, 60 Hz, 120 volt electrical service. Motors shall be 1750 RPM, squirrel cage, normal starting torque and normal starting current, in accordance with NEMA standards unless otherwise specified.

B. All T-frame, ODP motors 5 HP and above shall be premium efficiency motors with a minimum power factor of 0.85 on 1800 RPM motors and a minimum efficiency rating in accordance with IEEE Standard 112, Test Method 'B' as scheduled below. In addition, all motors used in conjunction with variable frequency drives shall be premium efficiency.

NEMA EFFICIENCY	
Motor Horsepower	Efficiency, Minimum
5	90.2
7-1/2	91.0
10	91.7
15	92.4
20	93.0
25	92.4
30	93.0
40	93.6
50	93.6
60	93.6
75	95.0
100	95.4
125 & 150	95.8

C. Motors, including premium efficiency motors shall be manufactured by General Electric Baldor, Louis Allis (Spartan), Marathon, Reliance Electric, Westinghouse, or equivalent having equal efficiencies.

D. Special motors as may be necessary by the application and as specified herein and on the drawings include C-FACE, totally enclosed fan cooled (TEFC),explosion-proof, etc., shall be provided as required and shall be furnished manufacturer's premium efficiency rating for 5 HP and larger.

E. Each motor shall be of the horsepower as specified and suitable for use at an altitude of 7000 feet. All motors shall have grease lubricated sealed ball bearings. Motors larger than 1 HP shall have a standard grease fitting "Zerk" and a separate grease relief tapping. Motors shall be factory lubricated. Motors shall be commercially dynamically balanced and tested at the factory before shipment and shall be selected for quiet operation. The Contractor shall line up motors and drives and place motors and equipment on foundations ready for operation.

F. Unless indicated otherwise, motors shall be NEMA design B with a service factor of 1.15 with 40^0C rise and total temperature rise of 65^oC ambient and when powered from the system voltage feeding the motor. TEFC motors shall have a service factor of 1.00 with total temperature rise of 65^oC in the above conditions. Motors located in areas exceeding 40^oC in the ambient shall be factory rated for the ambient temperature of the motor environment. Single phase motors shall generally be NEMA Type N split phase induction motors with built-in thermal protectors. Unless otherwise specified for a particular application use electric motors with the following requirements.

1. Single-phase Motors: Capacitor-start type for hard starting applications. Motors for centrifugal fans and pumps may be split phase or permanent split capacitor (PSC).
2. Polyphase Motors: NEMA Design B, Squirrel cage, induction type. Each two speed motor shall have two separate windings.
3. Rating: Continuous duty at 100% capacity in an ambient temperature of 40^oC.

G. If the Division 22 Contractor proposes to furnish motors varying in horsepower and/or characteristics from those specified, he shall first submit his request for the change and shall then coordinate the change with Division 26 and shall pay all additional charges in connection with the change.

H. The Contractor shall ensure proper coordination between motors and variable frequency drives. See Section 220550 also.

2.5 ELECTRICAL WIRING AND CONTROL EQUIPMENT

A. All wiring and conduit shall be furnished and installed as scheduled in Section 220549, Plumbing and Electrical Installation Coordination, unless otherwise noted or directed.

B. The Contractor shall coordinate completely with all trades and Sub-Contractors as required to ensure that all necessary components of control work are included and fully understood. No additional cost shall accrue to the Owner as a result of lack of such coordination.

C. The piping system may be bonded to the electrical ground bus at the electrical service equipment, but shall not under any circumstances be used as the main grounding electrode for the electrical service.

2.6 PAINTING

A. All finish painting of plumbing systems and equipment will be under "Painting," unless equipment is hereinafter specified to be provided with factory applied finish coats.

B. All equipment shall be provided with factory applied prime finish, unless otherwise specified.

C. Touch-Up: If the factory finish on any equipment is damaged in shipment or during construction of the building, the equipment shall be refinished.

2.7 COUPLING GUARDS

A. All flexibly connected pumps shall be provided with protective steel coupling guards.

2.8 IDENTIFICATION OF VALVES

A. Each valve shall be provided with a stamped metal tag secured to the valve. Tag shall indicate the valve number, the service and function of each valve. The Contractor shall furnish two sets of prints of drawings showing floor plan for each floor with all valves accurately located and labeled. Submitted drawings shall be neat and easily readable. In addition, the Contractor shall provide a valve chart, typed neatly on 8-1/2" x 11" sheets, listing the number, size, location, function, normal operating position, on each valve installed under Division 22. Valves shall be listed by system, i.e. domestic cold water, hot water, chilled water etc. Tags shall be stamped brass 1-1/2" diameter, and secured to valves by heavy copper figure eight hooks, braided stainless steel wire anchor, or other approved means.

B. Division 22 valve tags shall be coordinated with Division 21 and Division 23 valve tags for coordinated format between each Division.

C. Valve tags shall be coordinated with existing facility valve tags and Contractor shall obtain a copy of existing facility valve chart and provide updated valve chart to the Owner’s Representative.

2.9 PIPING SYSTEM IDENTIFICATION

A. Means of Identification: All piping shall be identified by each of the means described below. The Contractor shall provide shop drawing submittal data for proposed labeling system materials and manufacturer's recommended installation procedures.

B. Piping Systems shall be identified by means of an identifying legend on color coded background appropriately worded to indicate the "service" name of the pipe as shown on the drawings. Color coded banding shall also be provided. Additionally, an arrow shall be included to indicate the direction of flow through the pipe.

C. Locations of Piping System Identification: The identifying legends and directional arrows described in the paragraphs preceding shall be located at the following points on each piping system:
- Adjacent to each valve in piping system.

- At every point of entry and exit where piping passes through a wall.
- On each pipe riser and junction.
- At a maximum interval of 20 feet on pipe lines exposed and concealed above accessible ceilings.
- Adjacent to all special fittings (regulating valves, etc.) in piping systems.
- At every access door.

D. Piping identification shall meet the standards of the Federal Occupational Safety Health Act (OSHA) which refers to the ANSI Standard A13.1. The following standardized color code scheme shall be used:

Yellow	- Hazardous Materials
Green	- Liquid Materials of Inherently Low Hazard
Blue	- Gaseous Materials of Inherently Low Hazard
Red	- Fire Protection Materials

E. The size of letter and length of color field shall conform to the ANSI standard and shall be as follows:

Outside Diameter of Pipe or Covering	Length of Color Field	Size of Letters
3/4" to 1-1/4"	8"	1/2"
1-1/2" to 2"	8"	3/4"
2-1/2" to 6"	12"	1-1/4"
8" to 10"	24"	2-1/2"
Over 10"	32"	3-1/2"

F. All pipe labels shall be vinyl material with permanent adhesive for application to clear dry pipe and/or insulation jacketing. Each label shall have appropriate color-coded background with printed legend. Direction arrows shall be placed next to label to indicate flow direction. Color and size of arrows shall correspond to that of label. Pressure sensitive pipe tape matching the background color of the label shall be placed over each end of the label and completely around the pipe.

G. Attach pipe markers to lower quarter of the pipe on horizontal runs and on the centerline of vertical piping where view is not obstructed. Flow indicator arrow shall point away from pipe marker.

H. Provide the following labels, with ANSI/OSHA color for all piping systems as shown on the drawings and as listed below:

Service/Legend	Letter Color	Background Color
Domestic Cold Water	White	Green
Domestic Hot Water	Black	Yellow
Domestic Hot Water Return	Black	Yellow
Industrial (non potable) Cold Water	White	Green
Roof Drain	White	Green
Sanitary Sewer	White	Green
Storm Sewer	White	Green

2.10 IDENTIFICATION OF CONTROL SYSTEM DEVICES

A. All automatic controls, control panels, zone valves, pressure electric, electric pressure switches, relays and starters shall be clearly tagged and identified. Wording shall be identical to that on the control diagram in the contract drawings.

2.11 UNDERGROUND PIPING SYSTEM IDENTIFICATION

A. Bury a continuous, preprinted, bright colored, plastic ribbon cable marker with each underground pipe regardless of whether encased. Locate directly over buried pipe, 6" to 8" below finished grade. Marker tape used in conjunction with buried plastic piping systems shall be special detector type. Marker tape used in conjunction with buried plastic piping systems shall be special detection type.

2.12 EQUIPMENT TAGS

A. Furnish and install equipment identification tags for all items of PLUMBING equipment furnished and installed under Division 22. Equipment tags shall be a minimum of 3/32" thick laminated phenolic plastic.

2.13 ACCESS DOORS

A. Provide all access doors required for access to valves, controls, or other items for which access is required for either operation or servicing. All costs incurred through failure to perform this function as the proper sequence of this work shall be borne by the Contractor. The type of access door shall be as required by the room finish schedule. Acoustical tile access doors shall be equal to Krueger Style B, Style A for acoustical plaster, Style C-CE for sidewall drywall or plaster construction, or Milcor institutional 10 gauge security/detention access door with welded joints, welded butt hinge, with detention type deadbolt lock and tamperproof screws.

B. Access doors shall be not less than 12" x 12" in size except that larger panels shall be furnished where required, and panels in tile or other similar patterned ceilings shall have dimensions corresponding to the tile or pattern module.

C. Where access doors are installed in walls required to have a specific fire rating, the access door installed shall be a fire rated access door with UL label, as manufactured by Milcor or equivalent. Access door in 1-hour construction shall be Class C and access doors in 2-hour construction shall be Class B.

PART 3 - EXECUTION

3.1 COOPERATION WITH OTHER TRADES

A. The Contractor shall refer to other parts of these specifications covering the work of other trades

which must be carried on in conjunction with the plumbing work so that the construction operations can proceed without harm to the Owner from interference, delay, or absence of coordination. The Contractor shall be responsible for the size and accuracy of all openings.

B. Provide submittals as required by Section 01 8113 Supplemental Table
   1. Submittal Requirements for LEED v4 Environmental Quality Credits.

3.2 DRAWINGS

A. The plumbing drawings show the general arrangement of all piping, fixtures, equipment, etc., and shall be followed as closely as actual building construction and work of other trades will permit. Whenever discrepancies occur between plans and specifications, the most stringent shall govern. All Contract Documents, including but not limited to Division 21 Fire Suppression, Division 23 HVAC, and Division 26 Electrical shall be considered as part of the work insofar as this information furnishes the Contractor with details relating to design and construction of the building. Architectural and Structural drawings shall take precedence over the plumbing, HVAC and fire suppression drawings. Install plumbing fixtures, floor drains, floor sinks, roof drains, etc. in locations as indicated on Architectural drawings. Because of the small scale of the plumbing, HVAC and fire suppression drawings, it is not possible to indicate all offsets, fittings and accessories which may be required. The Contractor shall investigate the structural and finish conditions affecting the work and shall arrange his work accordingly, providing such fittings, valves, and accessories as may be required to meet such conditions. Should conditions necessitate a rearrangement of piping, such departures and the reasons therefore shall be submitted by the Contractor for review in the form of detailed drawings showing the proposed changes. No such changes shall be made without the prior written approval. All changes shall be marked on the set of record drawings by the Contractor.

B. Should any doubt or question arise in respect to the true meaning of the drawings or specifications, the question shall be submitted in writing.

C. Installation of all plumbing equipment and piping systems shall be arranged to provide all clearances required for equipment operation, service, and maintenance, including minimum clearances required by applicable codes, manufacturer's installation instructions and as necessary for proper clearance in front of all electrical panels as defined by the National Electric Code (NEC). Piping systems shall not be routed through or above electrical equipment room or electrical equipment space designed within equipment rooms.

D. The Contractor's attention is directed to the unique architectural design features and consideration associated with this facility which will require significantly greater levels of coordination and cooperation for the work furnished and installed under Division 22 with the associated architectural, structural, and electrical work than is normally necessary for a more typical facility.

E. The installation of all concealed plumbing systems shall be carefully arranged to fit within the available space without interference with adjacent structural and electrical systems. The Contractor shall make all necessary provisions for penetrations of piping, including sleeves and blockouts in structural systems. The exact location of all exposed plumbing systems; access doors; piping exposed within finished areas; and other equipment and devices as applicable, shall be coordinated with the Architect, who shall have final authority for the acceptance of the work as it specifically

relates to the architectural aesthetic design requirements for the facility. In no instance shall the building vapor barrier system be penetrated by the plumbing system installation without written approval.

3.3 FIELD MEASUREMENTS

A. The Contractor shall verify the dimensions and conditions governing his work at the building. No extra compensation shall be claimed or allowed on account of differences between actual dimensions, including dimensions of equipment, fixtures and materials furnished, and those indicated on the drawings. Contractor shall examine adjoining work, on which his work is dependent for perfect efficiency, and shall report any work which must be corrected. Coordination of all plumbing work within the building will be the direct responsibility of the Contractor. Review of submittal data in accordance with paragraph "Submittals" shall in no manner relieve the Contractor of responsibility for the proper installation of the plumbing work within the available space. Installation of equipment and systems within the building space shall be carefully coordinated by the Contractor with all building trades. Each contractor shall so harmonize his work with that of the several other trades that it may be installed in the most direct and workmanlike manner without hindering or handicapping the other trades. Piping interferences shall be handled by giving precedence to pipe lines which require a stated grade for proper operation. Sewer lines shall take precedence over water lines in determination of elevations. In all cases, lines requiring a stated grade for their proper operation shall have precedence over electrical conduit and ductwork. Installation of plumbing, HVAC and fire suppression equipment within the ceiling cavity shall be in the following order of priority: plumbing waste lines; roof drains; supply, return, outside air, makeup, and exhaust ductwork; fire sprinkler mains; fire sprinkler branch piping and sprinkler runouts; heating hot water and chilled water piping; domestic hot and cold water; control piping, wiring and conduit; miscellaneous special piping systems.

3.4 EQUIPMENT SUPPORT

A. Contractor shall provide support for equipment to the building structure. Contractor shall furnish all necessary structures, inserts, sleeves, and hanging devices for installation of mechanical and plumbing equipment, ductwork and piping, etc. Contractor shall completely coordinate installation of such devices with all trades and Sub-Contractors. Contractor must further verify that the devices and supports are adequate as intended and do not overload the building's structural components in any way.

3.5 PROTECTION OF MATERIALS AND EQUIPMENT

A. The Contractor shall be responsible for the protection of all work, materials and equipment furnished and installed under this section of the specifications, whether incorporated in the building or not.

B. Plumbing equipment and materials, including piping, valves and fittings, etc., shall be protected from damage and contamination. Equipment and materials shall not be stored outside and exposed to weather and ambient conditions without appropriate protection measures and without the approval of the Architect and Owner’s Representative. Equipment and materials shall be delivered to the jobsite and maintained while on the jobsite with all openings, controls and control panels covered with caps, with heavy duty polyethylene wrap or other proper means. Equipment and materials

where stored within the building shall be protected at all times from construction damage and contamination from dust, dirt, debris, and especially during fireproofing, painting and gypboard sanding and finishing. Unprotected equipment and piping will require special field cleaning by the Contractor prior to acceptance by the Architect and Owner's Representative.

C. The Contractor shall provide protection for all work where necessary and shall be responsible for all damage done to property, equipment and materials. Storage of materials within the building shall be approved by the Architect and Owner's Representative prior to such storage.

D. Pipe openings shall be closed with caps or plugs, or covered to prevent lodgment of dirt or trash during the course of installation. At the completion of the plumbing work, fixtures and materials shall be cleaned and polished thoroughly and delivered in a condition satisfactory to the Architect and Owner's Representative.

3.6 TRENCHING AND BACKFILLING

A. All excavation, trenching and backfilling required for the plumbing installation shall be provided by this Contractor.

3.7 MANUFACTURER'S INSTRUCTIONS

A. All equipment shall be installed in strict accordance with recommendations of the manufacturer. If such recommendations conflict with plans and specifications, the Contractor shall report such conflicts to the Architect, who shall make such compromises as he deems necessary and desirable.

3.8 CONCRETE BASES AND HOUSEKEEPING PADS

A. Concrete bases and housekeeping pads shall be installed under all pieces of plumbing equipment unless specifically deleted by the specifications or drawings.

B. Contractor shall be responsible for the accurate dimensions of all pads and bases and shall furnish and install all vibration isolators, anchor bolts, etc.

C. Contractor shall provide concrete housekeeping pad foundations for all floor mounted equipment installed under this section unless otherwise shown on the drawings. All concrete bases and housekeeping pads shall conform to the requirements specified under Division 3, Concrete, portions of these specifications. Pad foundations shall be 4" high minimum, unless otherwise indicated on the drawings. Chamfer edges shall be 1". Faces shall be free of voids and rubbed smooth with carborundum block after stripping forms. Tops shall be level. Provide dowel rods in floor for lateral stability and anchorage.

D. Equipment anchor bolts shall be set in a galvanized pipe or sheet metal sleeves 1" larger than bolt diameter. Anchor bolts shall be high strength steel J shape. Anchor bolt design shall be arranged and paid for by the Contractor.

E. Machinery bases, bed plates, sole plates, or vibration isolation units shall be carefully aligned,

shimmed, leveled, then grouted in place with commercial non-shrink grout. When a flexible coupling is employed as a part of the drive train, the coupling shall be aligned before the machinery base is grouted.

3.9 ALIGNMENT OF FLEXIBLE COUPLINGS

A. Flexible couplings between motors and driven equipment shall be aligned by the qualified service technician after the equipment is installed and ready for operation. Proper aligning shall be provided within manufacturer's maximum alignment tolerance at equipment operating conditions and temperature. Alignment shall follow unit manufacturer's written procedures using approved dial indication methods for parallel and angular alignment. The Contractor shall provide written certification that each device has been so aligned.

3.10 LUBRICATION

A. The Contractor shall provide all oil for the operation of all equipment until acceptance. The Contractor shall be held responsible for all damage to bearings while the equipment is being operated by him up to the date of acceptance of the equipment. The Contractor shall protect all bearings and shafts during installation and shall thoroughly grease the steel shafts to prevent corrosion. Bearings for items of plumbing equipment shall be marked at each bearing location as to whether the bearing is a sealed type or relubricable type unit.

3.11 PRESSURE RELIEF DEVICES

A. Pressure relief devices and fusible plugs shall be installed with piping to a safe location in accordance with Code requirements.

3.12 TESTS

A. Tests shall be conducted in the presence of the designated and authorized Owner's Representative. The Contractor shall notify the Architect and Owner’s Representative a minimum of one week in advance of scheduled tests. Requirements for testing are specified under the sections covering the various systems. The Contractor shall furnish all necessary equipment, materials, and labor to perform the required tests.

3.13 INSTALLATION CHECK

A. An experienced, competent, and authorized representative of the equipment listed below shall visit the site of the work and inspect, check, adjust if necessary, and approve the equipment installation. In each case, the equipment supplier's representative shall be present when the equipment is placed in operation. The equipment supplier's representative shall revisit the job site as often as necessary until all trouble is corrected and the equipment installation and operation is approved and accepted.

B. Each equipment supplier's representative shall furnish a written report certifying that the equipment (1) has been properly installed and lubricated; (2) is in accurate alignment; (3) is free from any undue stress imposed by connecting piping or anchor bolts; and, (4) has been operated under full

load conditions and that it has operated satisfactorily.

C. Equipment requiring installation check includes the following:

End Suction Pumps
Domestic Water Heaters

3.14 OPERATION AND MAINTENANCE INSTRUCTIONS

A. The Contractor shall furnish complete operating and maintenance instructions covering all units of plumbing equipment fixtures, faucets, etc., herein specified together with parts lists. Equipment spare parts shall include all components requiring service, including motors, bearings, shafts, etc. A "Lubrication Chart" framed under Plexiglass shall be provided listing all types of oil to be used for each piece of equipment and the recommended frequency of lubrication. This chart shall be hung on the wall of the equipment room.

B. See Division 1 for additional requirements concerning manuals, manual distribution, and maintenance materials.

C. Operating and maintenance manuals as required herein shall be submitted for review and distribution to the Owner not less than two (2) weeks prior to the date scheduled for the Contractor to provide Operating and Maintenance Instructions to the Owner as specified herein.

D. Upon completion of all work and all tests, Contractor shall furnish the necessary skilled labor and helpers for operating the plumbing systems and equipment for a period of five (5) days of eight (8) hours each. During this period, the Contractor shall instruct the Owner or his representative fully in the operations, adjustment and maintenance of all equipment furnished. Contractor shall provide at least two weeks notice in advance of this period, with a written schedule of each training session, the subject of the session, the Contractors' representatives who plan to attend the session, and the time for each session.

E. Operational test shall be conducted by the Contractor with the assistance of the equipment manufacturer's representative or service technician. Test shall be conducted in the presence of the designated and authorized Owner's Representative.

3.15 CERTIFICATIONS

A. Before receiving final payment, the Contractor shall certify in writing that all equipment furnished and all work done is in compliance with the contract documents and all applicable codes. Submit certifications and acceptance certificates, including proof of delivery of O&M manuals, spare parts required, and equipment warranties which shall be bound with O&M manuals.

3.16 OPERATION PRIOR TO ACCEPTANCE

A. Operation of equipment and systems installed by the Division 22 Contractor, for the benefit of the Contractor, except for the purposes of testing and balancing will not be permitted without a written agreement between the Owner and the Contractor establishing warranty and other responsibilities.

3.17 SITE VISITS AND OBSERVATION OF CONSTRUCTION

A. The design professional shall make periodic visits to the project site at various stages of construction in order to observe the progress and quality of various aspects of the Contractor's work, in order to determine in general if such work is proceeding in accordance with the Contract Documents. This observation, however, shall in no way release the Contractor from his complete responsibility to supervise, direct, and control all construction work and activities. The design team has no authority over, or a responsibility to means, methods, techniques, sequences, or procedures of construction provided by the Contractor or for safety precautions and programs, or for failure by the Contractor to comply with all law, regulations, and codes.

B. Prior to the "Final" observation visit, the attached "Final Observation Checklist" shall be completed by the Contractor. Any non-applicable items shall be marked "N/A." The completed form shall be submitted, indicating that all necessary items are complete and requesting a final observation within 10 days. The Contractor shall be notified of any uncompleted items within seven (7) days. A resubmittal of the form and a new final observation request by the Contractor is required if the form is returned and noted as incomplete.

END OF SECTION 22 0500

Project:_____ **Date Submitted:**_____
General Contractor:_____ **Date of Final Mechanical System:**_____
Mechanical Contractor:_____ **Observation Requested:**_____

CONTRACTOR'S MECHANICAL & PLUMBING CHECK LIST
(ALL APPLICABLE ITEMS MUST BE COMPLETED PRIOR TO FINAL OBSERVATION)

In advance of requesting a final mechanical observation for installed mechanical systems, please check all items that have been completed. For all items not applicable to this project mark N/A.

HVAC/PIPING

_____1. All plumbing fixtures are set, sealed and cleaned.

_____2. All domestic pipe systems are insulated.

_____3. All pipe systems are identified with specified labels and directional arrows.

_____4. Floor sinks and drain grates are cleaned and debris removed.

_____5. Valve tags are installed.

_____6. Special equipment (water softeners, water heaters, piping systems, etc.) have been checked and put into service.

_____7. Medical gas systems have been checked and certified.

_____8. Special piping systems have been cleaned and pressure tested.

_____	Process Piping	_____	Nitrogen
_____	Compressed Air	_____	Vacuum
_____	Natural Gas	_____	Argon
_____	Other	_____	Medical Gas
		_____	Other

_____9. Limestone chips have been installed in acid dilution sumps.

_____10. Plumbing/piping connections have been completed to Owner furnished equipment and equipment furnished by other Contractors/Sub-Contractors.

_____11. Exterior wall hydrants have been cleaned.

_____12. Concrete collars have been installed at clean-out to grade, valve box, or other specified plumbing items.

_____13. Drains and relief lines from plumbing equipment have been installed and secured in a proper manner.

_____14. All plumbing equipment and areas of equipment have been cleaned and debris removed.

_____15. All plumbing equipment required by the Specifications has been identified and/or numbered.

_____16. Domestic water systems sterilization has been completed.

_____17. Strainers/suction diffusers have been cleaned.

_____18. Backflow preventers have been tested.

_____19. Air has been vented from all systems.

_____20. Ethylene glycol system has been charged with correct mixture and tested.

_____21. Water systems have been cleaned (X) and pressure tested (P).

_____	Non-potable Water	_____	Domestic Hot Water
_____	Domestic Cold Water	_____	Acid Waste and Vent
_____	Sanitary Sewer & Vent	_____	Roof and Overflow Drains
_____	Other (list)		

_____22. PRV's have been adjusted (water, gasses).

PLUMBING EQUIPMENT

_____1. All pump shafts and couplings have been aligned.

_____2. Boilers and domestic water heaters have been fired and tested.

_____3. All plumbing equipment has been lubricated.

_____4. Plumbing equipment has been labeled in accordance with the specifications.

_____5. "HAZARDOUS AREA" signs installed where applicable.

_____6. Variable frequency drives have been tested by the manufacturer's representative and certified to be in compliance with all of the specified requirements.

GENERAL ITEMS

The following specified items have been submitted:

_____1. Record drawings (to be submitted prior to final payment to the Contractor).

_____2. Operation and maintenance manuals.

_____3. Manufacturer's representative installation check and certification submitted (see list of equipment, Section 22 0500).

_____4. Test kits furnished to Owner.

_____ Flow Measuring Devices
_____ Flow Balance Valves
_____ Flow Control Devices

_____5. Control schematics and sequence of operation.

_____6. Plumbing equipment and lubrication, valve, charts have been provided to Owner's Representative.

END CHECKLIST

DIVISION 22 SUBSTITUTION REQUEST FORM (SRF)

TO: **BRIDGERS & PAXTON CONSULTING ENGINEERS, INC.**
PROJECT: _____

We hereby submit for your consideration the following product instead of the specified item for the above project:
Section: _____ Page: _____ Paragraph/Line: _____ Specified Item: _____
Proposed Substitution: _____

Attach complete product description, drawings, photographs, performance and test data, and other information necessary for evaluation. Identify specific Model Numbers, finishes, options, etc.

1. Will changes be required to building design in order to properly install proposed substitutions? YES ☐ NO ☐
   If YES, explain: _____

2. Will the undersigned pay for changes to the building design, including engineering and drawing costs, caused by requested substitutions? YES ☐ NO ☐

3. List differences between proposed substitutions and specified item.

Specified Item	Proposed Substitution

4. Does substitution affect Drawing dimensions? YES ☐ NO ☐

5. What affect does substitution have on other trades? _____

6. Does the manufacturer's warranty for proposed substitution differ from that specified? YES ☐ NO ☐
   If YES, explain: _____

7. Will substitution affect progress schedule? YES ☐ NO ☐
   If YES, explain: _____

8. Will maintenance and service parts be locally available for substitution? YES ☐ NO ☐
   If YES, explain: _____

9. Does proposed product contain asbestos in any form? YES ☐ NO ☐

SUBMITTED BY: Firm: _____ Date: _____
Address: _____
Signature: _____ Telephone: _____

For Engineer's Use Only
Accepted _____ Not Accepted: _____ Received too Late: _____
By: _____ Date: _____
Remarks: _____

LICENSE AGREEMENT FOR CADD DATABASE OR BIM MODEL

PROJECT: _____

LICENSE GRANT: Contractor is granted use of the CADD Database or BIM Model (Database/Model) for the indicated project for the specific purpose of preparing submittal documents for this Project. No other use of the Database/Model is granted. Title to the Database/Model is not transferred to the Contractor. The Database/Model may be of value to the Contractor in preparing submittals, but use of the model does not relieve the contractor of the requirement to verify measurements in the field.

COPYING RESTRICTIONS: Contractor may copy the Database/Model in whole or in part, but only for backup and archival purposes or for use by the Contractor's Subcontractors. Contractor agrees to ensure that any entities that receive the Database/Model from Contractor, either in whole or in part, comply with the terms and conditions of this agreement. Contractor shall safeguard the Database/Model from falling into the hands of parties other than Subcontractors with a legitimate need for it.

WARRANTY: Bridgers & Paxton (B&P) offers this Database/Model without warranty and specifically without express or implied warranty of fitness. If Contractor chooses to use the Database/Model, then he does so at his own risk and without any liability or risk to B&P.

INDEMNITY: Contractor shall to the fullest extent permitted by law, defend, indemnify and hold harmless the Owner, Architect, B&P, their employees and agents from all claims, damages, losses, and attorney fees arising out of or resulting from the use of the Database/Model.

ACKNOWLEDGMENT: Contractor acknowledges that (s)he has read this Agreement, understands it, and agrees to be bound by its terms and conditions.

CONTRACTOR'S REPRESENTATIVE

Signature: _____ Company Name: _____

Name: _____ Address 1: _____

Title: _____ Address 2: _____

Date: _____

SECTION 22 0503 - TRENCHING AND BACKFILLING FOR PLUMBING

PART 1 - GENERAL

1.1 REQUIREMENTS

A. Conform with applicable provisions of the General Conditions, Supplemental General Conditions and the General Requirements.

1.2 SCOPE OF WORK

A. The work in this section includes the furnishing of all labor, materials, equipment, transportation, hauling and services required in connection with the excavation, backfilling, compaction, grading and removal of earth from the site required for the installation of the mechanical work specified herein under Division 22.

1.3 SAFETY REGULATIONS

A. All work performed under this Section shall conform to the requirements of the General Conditions, Supplementary Conditions and Safety Requirements for this type of work.

PART 2 - PRODUCTS

Not Applicable.

PART 3 - EXECUTION

See Division 23, Section 230503 – Trenching and Backfilling, for applicable requirements.

END OF SECTION 22 0503

SECTION 22 0504 - PIPE AND PIPE FITTINGS FOR PLUMBING

PART 1 - GENERAL

1.1 REQUIREMENTS

A. Conform with applicable provisions of the General Conditions, Supplemental General Conditions and General Requirements.

B. Lead Ban: All systems and system components, pipe, fittings, and fixtures delivering water for human consumption shall be lead free.

1. Any product designed for dispensing potable water shall meet both the NSF 61 and NSF 372 test standards via third-party testing and certification.
2. Lead free refers to <0.25% weighted average lead content in relation to wetted surface of pipe, fittings, and fixtures in systems delivering water for human consumption, and solder and flux which does not contain more than 0.2% lead.

1.2 RELATED SECTIONS

A. Section 220500, Common Work Requirements for Plumbing.

1.3 SUBMITTAL DATA

A. Contractor shall furnish complete submittal data for all piping materials, including manufacturer's specifications, certifications, class, type and schedule. Submittal data shall additionally be furnished for pipe hangers and supports, pipe sleeves including sealing and fire safing materials and installation.

PART 2 - PRODUCTS

See Division 23, Section 230504 – Pipe and Pipe Fittings, for applicable requirements.

PART 3 - EXECUTION

See Division 23, Section 230504 – Pipe and Pipe Fittings, for applicable requirements.

END OF SECTION 22 0504

SECTION 22 0505 - PIPING SPECIALTIES FOR PLUMBING

PART 1 - GENERAL

1.1 REQUIREMENTS

A. Contractor shall furnish and install all piping specialties necessary for satisfactory operation of the systems. Conform with applicable provisions of the General Conditions, Supplemental General Conditions and General Requirements.

B. Lead Ban: All systems and system components, pipe, fittings, and fixtures delivering water for human consumption shall be lead free.

1. Any product designed for dispensing potable water shall meet both the NSF 61 and NSF 372 test standards via third-party testing and certification.
2. Lead free refers to <0.25% weighted average lead content in relation to wetted surface of pipe, fittings, and fixtures in systems delivering water for human consumption, and solder and flux which does not contain more than 0.2% lead.

1.2 RELATED SECTIONS

A. Section 220500, Common Work Requirements for Plumbing.

B. Section 220504, Pipe and Pipe Fittings for Plumbing.

C. Section 220523, Valves for Plumbing.

D. Section 220700, Plumbing Insulation.

E. Section 220549, Plumbing and Electrical Installation Coordination.

1.3 SUBMITTAL DATA

A. The Contractor shall furnish complete submittal data for all piping specialties including manufacturer's specifications, performance characteristics, ratings, installation instructions, certifications and approvals of listing agencies, wiring diagrams, and selection analysis.

PART 2 - PRODUCTS

See Division 23, Section 230505, Piping Specialties.

PART 3 - EXECUTION

See Division 23, Section 230505, Piping Specialties.

END OF SECTION 22 0505

SECTION 22 0523 - VALVES FOR PLUMBING

PART 1 - GENERAL

1.1 REQUIREMENTS

A. All Valves shall conform with current applicable provisions of the General Conditions, Supplemental General Conditions, and General Requirements.

B. All Valves shall meet the current MSS Specifications covering Bronze & Iron Valves. MSS-SP-80, MSS-SP-70, MSS-SP71, MSS-SP-85 where applicable.

C. Lead Ban: All systems and system components, pipe, fittings, and fixtures delivering water for human consumption shall be lead free.

1. Any product designed for dispensing potable water shall meet both the NSF 61 and NSF 372 test standards via third-party testing and certification.
2. Lead free refers to <0.25% weighted average lead content in relation to wetted surface of pipe, fittings, and fixtures in systems delivering water for human consumption, and solder and flux which does not contain more than 0.2% lead.

1.2 RELATED SECTIONS

A. Section 220500, Common Work Requirements for Plumbing.

B. Section 220504, Pipe and Pipe Fittings for Plumbing.

C. Division 21 for Fire Suppression System.

D. Division 22 for Plumbing.

1.3 SCOPE

A. Contractor shall furnish and install all valves and accessories necessary for satisfactory operation of the systems.

1.4 VALVE REQUIREMENTS

A. All Gate, Globe, Check, Ball valves shall be manufactured by Milwaukee, Nibco, Apollo, Stockham, Powell, Crane, Grinnell, or equivalent.

B. All lubricated plug valves shall be as manufactured by Rockwell, Walworth, Homestead, or equivalent.

C. Ball valves shall be utilized in lieu of gate valves and globe valves for all plumbing systems for sizes 2" and smaller.

D. All valves furnish under Division 22 and 23 of the same type shall be products of a single manufacturer [unless otherwise approved by Owner's Representative.

E. Provide gate and globe valves with packing that can be replaced with the valve under full working pressure.

PART 2 - PRODUCTS

See Division 23, Section 230523 - Valves, for applicable requirements.

PART 3 - EXECUTION

See Division 23, Section 230523 - Valves, for applicable requirements.

END OF SECTION 22 0523

SECTION 22 0549 - PLUMBING AND ELECTRICAL INSTALLATION COORDINATION

PART 1 - GENERAL

1.1 REQUIREMENTS

A. Conform with applicable provisions of the General Conditions, Supplemental General Conditions and General Requirements.

1.2 RELATED DIVISIONS AND SECTIONS

A. Section 220500, Common Work Requirements for Plumbing.

B. Section 230900, Facility Management System.

C. Division 26 for Electrical.

D. Division 28 for Electronic Safety and Security.

1.3 SCOPE

A. It is the intention of this section to summarize the coordination of effort defined in the related sections and divisions of this specification.

B. If there is a conflict between this Section and other Sections and Divisions of this specification, this Section shall be the governing and decisive Section.

C. Make all connections to motors and controls for equipment supplied and/or installed under Division 22 according to Table 1 on the following page.

PART 2 - PRODUCTS

Not Applicable.

PART 3 - EXECUTION

3.1 INSTALLATION

A. No work shall be performed until the reviewed and marked submittal data have been reissued to the Contractor, unless written permission is obtained from the Architect.

TABLE 1

Item or System	Note	Supplied By (3)	Installed By (3)	Powered By	Control Field Wiring By
Equipment Motors		Div. 22	Div. 22	Div. 26	N/A
Motor Control Center Including Starters, Pilot Lights, Heater, Switches, Auxiliary Contacts, and Internal Control Wiring		Div. 26	Div. 26	Div. 26	Div.23
Stand Alone Motor Starters (outside motor control centers)	(1)	Div. 26	Div. 26	Div. 26	Div. 23
Variable Frequency Drives (VFD's)		Div. 22	Div. 22	Div. 26	Div. 23
Fused and Non-Fused Disconnects	(1)	Div. 26	Div. 26	Div. 26	N/A
Control Relays & Control Transformers	(1)	Div. 22	Div. 22	Div. 26	Div. 23
Boilers & Domestic Water Heaters		Div. 22	Div. 22	Div. 26	Div. 23
Facility Management System (FMS) for Automatic Control and/or Monitoring of Plumbing System & Equipment	(2)	Div. 23	Div. 23	Div. 26	Div. 23

TABLE NOTES:

1. Unless specified to be supplied with the equipment
2. Division 26 shall coordinate with Division 23, FMS Contractor as required to provide 120 VAC power to each mechanical space and the central plant as necessary for the FMS and as shown on the drawings. Any additional power, transformers, and distribution shall be provided by the Section or Division indicated.
3. Division 22 indicates the plumbing contractor or their designated representative including equipment suppliers, sub-contractors, etc.

END OF SECTION 22 0549

SECTION 22 0700 - PLUMBING INSULATION

PART 1 - GENERAL

1.1 REQUIREMENTS

A. Conform with applicable provisions of the General Conditions, Supplemental General Conditions and General Requirements.

B. Materials shall conform to applicable ASTM standards.

1.2 RELATED SECTIONS

A. Section 220500, Common Work Requirements for Plumbing.

B. Section 220504, Pipe and Pipe Fittings for Plumbing.

1.3 SCOPE

A. All condensate pipe and fittings domestic hot water pipe including circulating hot water, interior roof drains including roof drain bowls, interior overflow roof drains including overflow roof drain bowls, domestic cold water including non-potable water piping, water piping located outdoors exposed to ambient freezing conditions.

B. Equipment covering, including pumps, domestic water heater stacks and breeching.

C. Plastic Piping Systems.

1.4 FITTINGS

A. All fittings except as otherwise specified, shall be insulated with the same material and thickness as specified for the pipe.

B. Unions, flanges and valves on hot water, will not require insulation.

1.5 TESTING

A. All piping shall be tested in accordance with the applicable Specification Sections, before any insulation is applied.

PART 2 - PRODUCTS

2.1 INSULATION

A. Insulation shall be as manufactured by Owens-Corning Fiberglas, Knauf, CertainTeed, Johns Manville, or Armstrong, or equivalent, and shall be equal to that specified below. Insulation and all materials on the interior and exterior surfaces of ducts, pipes, and equipment shall have a composite fire and smoke hazard rating not exceeding: Flame spread - 25; fuel contribution - 50; smoke developed - 50, as determined in accordance with ASTM Standard E-84. All insulation materials used for valves and fittings shall have the same ratings as the pipe insulation. Information must be submitted by means of manufacturer's literature showing that the proposed materials conform to above specification without exception.

B. Fiberglass pipe insulation shall be rigid molded and non-combustible with 'K' factor of 0.23 at 75°F. Jacket shall be all service (ASJ) vapor barrier jacket with white kraft paper reinforced with glass fiber yarn and bonded to aluminum foil, secured with self sealing longitudinal laps and butt strips. Johns Manville 'Micro-Lok' or equivalent.

C. Hydros Calcium Silicate insulation shall be rigid molded, non-combustible per ASTME 136, conforming to ASTM 533, asbestos-free with 'K' factor of 0.40 at 300°F., maximum service temperature 1200°F., compression strength (block) minimum of 200 PSI to produce 5% compression at 1-1/2" thickness. Johns Manville 'Thermo-12 Gold' or equivalent.

D. Fiberglass rigid board insulation for equipment shall conform to ASTM C612 with 'K' factor of 0.23 at 75°F, R=8.0 minimum, 3.0 pound per cubic foot density. Provide vapor barrier jacket (FSK) with aluminum foil reinforced with fiberglass yarn and laminated to fire-resistant kraft, secured with UL listed pressure sensitive tape and outward clinched expanded staples and vapor barrier mastic. Johns Manville 'Spin-Glas' or equivalent.

E. Elastomeric foam insulation for piping and equipment shall be flexible, cellular, molded or sheet, conforming to ASTM C534, with 'K' factor of 0.28 at 75°F., maximum service temperature of 220°F., maximum flame spread rating of 25 and maximum smoke development rating of 50 (3/4" thickness and less). Connections shall be made using manufacturer's approved waterproof vapor barrier retarder adhesive. Provide outdoor U.V. protective coating on all insulation exposed to ambient conditions.

2.2 FITTINGS

A. Valves and fittings, where required to be insulated, shall be covered with the same insulation material and thickness as specified for the pipe insulation and finished with PVC covers.

B. Valves and fittings with systems specified to be covered with metal or canvas, or polyvinyl chloride (PVC) jacket shall be covered with material to match piping system jacketing.

C. Polyvinyl chloride (PVC) preformed fitting covers with fiberglass inserts shall be used on valves and fittings, except where metal or canvas jacket is required for piping system. PVC fitting covers shall be Zeston 2000 or equivalent, gloss white and shall have a composite fire and smoke hazard rating not exceeding; flame spread - 25; smoke development - 50. Connections shall be made using tacks and pressure sensitive color matching vinyl tape. Seams shall be on the bottom side of pipe and fittings.

2.3 PVC JACKETING

A. PVC jacketing shall be Zeston 2000 or equivalent, gloss white, 0.020 inch thickness, minimum, and shall have a composite fire and smoke hazard rating not exceeding; flame spread -25; smoke development -50. Connection shall be made using tacks and pressure sensitive color matching vinyl tape. Seams shall be on the bottom side of pipe and fittings.

2.4 CANVAS JACKETING

A. Canvas jacketing shall be UL listed fabric, six ounce per square yard, plain weave cotton, treated with fire retardant lagging adhesive.

2.5 PIPE HANGERS AND SUPPORTS

A. See Specification Section 220504 for requirements associated with hangers and supports for piping systems.

B. All insulated piping systems shall be provided with individual hangers sized to encircle the insulation. Hangers for domestic cold water and roof drains may be installed under the insulation, provided that the vapor barrier system for cold piping and the hanger rods are protected from the formation of condensation by application of a heavy coating of vapor barrier mastic material.

C. Insulated piping supported by means of trapeze hangers or roller type hangers shall not rest directly on the hanger or support.

D. The insulation at hangers, trapezes and supports shall be protected by means of galvanized steel insulation half diameter support shields. Provide insulation insert between support shield and piping for piping size 1-1/2" and larger. Insulation inserts shall be heavy density calcium silicate molded insulation. Insulation inserts shall be the following minimum lengths. Factory fabricated thermal pipe shield as manufactured by Pipe Shields, Inc., and specified in Section 220504, may be used at Contractor's option.

Pipe Size, In.	Insert Length
1-1/2" to 2-1/2"	10" Long
3" to 6"	12" Long
8" to 10"	16" Long
12" and larger	22" Long

2.6 PIPE SLEEVES

A. See Specification Section 220504 for requirements associated with pipe sleeves for piping penetrations for building walls and frames.

B. Pipe sleeves shall be provided at penetrations through concrete and masonry construction and at fire rated and smoke rated walls and penetrations when required to comply with UL approved

penetration assembly. Insulated piping passing through fire walls and smoke walls shall be provided with UL approved fire safing insulation to match the required insulation thickness and the space between the piping penetration and the adjacent wall construction shall be sealed air tight with UL approved fireproof caulking material. Pipe penetration arrangement and installation requirements shall match the applicable UL approved penetration assembly details.

PART 3 - EXECUTION

3.1 DOMESTIC HOT WATER PIPING

A. Domestic hot water piping with operating temperatures of 140°F and less, including recirculating hot water piping shall be insulated with 1-inch thick fiberglass preformed pipe insulation with All Service Jacket (ASJ). Fittings shall be finished with PVC fitting covers.

B. Insulation thickness for domestic and service water systems operating in excess of 140°F, shall be 1-inch thick fiberglass preformed pipe insulation with All Service Jacket (ASJ) for piping 3/4" through 3" size and 1-1/2" thick for piping 4" and larger. Fittings shall be finished with PVC fitting covers.

C. All voids formed by support saddles or other mounting or support hardware shall be filled with insulation.

3.2 DOMESTIC COLD WATER AND ROOF DRAINS

A. Domestic cold water piping and non-potable water piping shall be insulated with 1-inch thick fiberglass preformed pipe insulation with All Services Jacket (ASJ). Fittings shall be finished with PVC fitting covers. Cold water piping installed within interior partitions, not less than 10 feet from an exterior wall, and where no return air is present, need not be insulated.

B. Roof drain bowls and horizontal roof drain piping shall be insulated with 1-inch thick fiberglass insulation as specified for domestic cold water piping.

C. Overflow roof drain bowls and horizontal overflow roof drain piping shall be insulated with 1-inch thick fiberglass insulation as specified for domestic cold water piping.

D. All voids formed by support saddles or other mounting or support hardware shall be filled with insulation.

3.3 HANDICAP LAVATORY AND SINKS

A. Domestic hot and cold water piping and P-traps exposed below handicapped lavatories and sinks shall be insulated with HANDI LAV-GUARD insulation kits which satisfy ANSI A117.1 requirements. Insulation shall have a flexible vinyl finish which protects against burning and cushions impact.

B. Countertop sinks indicated within the Architectural drawings to be handicap-compliant shall have an off-centered drain opening and a maximum sink depth of 7-inches.

3.4 PLASTIC PIPING SYSTEMS

A. Plastic piping systems, including polypropylene acid waste, vent piping and PVC piping, installed within building return air plenums shall be insulated with 1/2" thick fiberglass preformed pipe insulation with All Service Jacket (ASJ). Fittings shall be insulated with preformed insulation fittings or, where preformed fittings are unavailable, neatly insulated with fiberglass duct wrap with white vinyl jacket.

B. All voids formed by support saddles or other mounting or support hardware shall be filled with insulation.

3.5 PVC JACKETING

A. PVC jacketing shall be installed on all field insulated plumbing equipment and on all piping systems exposed within the mechanical equipment spaces, where exposed to physical damage, and where noted on the drawings and specifications, except where metal or canvas jacketing is required.

B. Jacketing shall be secured in place in an approved manner by means of tacks and pressure sensitive tape.

C. Fittings and valves shall have insulation covered with PVC pre-molded PVC fittings to match jacketing, as specified below.

D. PVC jacketing shall not be permitted for use on exterior piping systems.

3.6 CANVAS JACKETING

A. Canvas jacketing shall be installed on all field insulated plumbing equipment and on all piping systems where noted on the drawings and specifications, except where metal or PVC jacketing is required.

B. Canvas jacket shall be adhered in place with fire retardant lagging adhesive and coating, to form a wrinkle free smooth continuous surface.

3.7 TERMINATION OF INSULATION

A. The termination of all insulation on pipes, at uninsulated valve connections, or unions, flexible connections, etc., shall be beveled and finished.

3.8 FACTORY INSULATED EQUIPMENT

A. Domestic water heaters and other equipment as specified in the equipment schedules on the drawings shall be factory insulated.

3.9 VICTAULIC COUPLINGS

A. Where Victaulic type couplings or similar piping systems are used, all couplings shall be insulated with insulation materials and thickness equal to the piping system. Insulation of couplings shall be as specified herein for fittings.

END OF SECTION 22 0700

SECTION 22 1100 - DOMESTIC WATER PIPING

PART 1 - GENERAL

1.1 REQUIREMENTS

A. Conform with the applicable provisions of the General Conditions, Supplemental General Conditions, and the General Requirements.

B. Lead Ban: All systems and system components, pipe, fittings, and fixtures delivering water for human consumption shall be lead free.

1. Any product designed for dispensing potable water shall meet both the NSF 61 and NSF 372 test standards via third-party testing and certification.
2. Lead free refers to <0.25% weighted average lead content in relation to wetted surface of pipe, fittings, and fixtures in systems delivering water for human consumption, and solder and flux which does not contain more than 0.2% lead. Solder shall be 95/5 tin antimony, alloy Sb5, conforming to FS QQ-S-571 and NSF 61.

1.2 RELATED SECTIONS

A. Section 220500, Common Work Requirements for Plumbing

B. Section 220504, Pipe and Pipe Fittings for Plumbing.

C. Section 220505, Piping Specialties for Plumbing.

D. Section 220523, Valves for Plumbing.

E. Section 220700, Plumbing Insulation.

F. Section 226801, Onsite Utilities, Plumbing.

G. Section 230900, Facility Management System.

H. Division 33 for Outside Utilities.

1.3 SCOPE

A. A complete domestic cold water, hot water, recirculating hot water, non-potable water and make-up water system including water heaters, pumps, thermal expansion tanks, backflow protection, shock absorbers, and associated miscellaneous accessories. This section shall include all work within the building to a point approximately 5'-0" outside the building, or as otherwise indicated.

B. Coordinate with Division 33 for site utility drawings and specifications.

PART 2 - PRODUCTS

2.1 PIPING

A. Domestic water piping including non-potable water piping, below grade or slab-on-grade shall be Type L soft copper, ASTM B88. Copper piping 2" and smaller shall be soft tubing and 2-1/2" thru 4" shall be either soft tubing or hard pipe. Domestic water piping 6" and larger below grade within the building and to a point approximately 5'-0" from the building shall be ductile iron pressure pipe, minimum 150 PSIG working pressure with mechanical joints.

B. Domestic water piping non-potable water piping above grade within the building 4" and smaller shall be Type L hard drawn copper, ASTM B88. Domestic water piping non-potable water piping larger than 4" shall be copper as specified herein or flanged ductile iron pipe.

C. Proper insulating fittings, as specified in Section 220504, shall be installed to prevent electrolytic action between steel and copper piping connections.

D. Domestic water piping, hot, hot water return, cold, and non-potable water may be Wirsbo Aquapex, cross linked polyethylene tubing, manufactured and listed to ASTM Standards F876 and F877. Installation shall meet all current codes and regulations and be performed by licensed plumbing installers who have successfully completed the Wirsbo Aquapex training course. Fittings, fire stopping, and complete installation shall be in strict compliance with manufacturer's latest recommendations. Materials and system shall be approved or accepted by BOCA, IAPMO, and ICBO. Piping shall be isolated from direct contact with building materials (wood, metal, etc.)

2.2 FITTINGS

A. Fittings for copper piping shall be wrought copper or cast brass conforming to ANSI B16.22 and B16.23, with 95-5 solder joints, as specified in Section 220504.

B. Mechanically formed tee connections and couplings for copper piping system as specified in Section 220504, may be utilized where approved.

C. Fittings for ductile iron pipe shall be flanged or mechanical joint conforming to ANSI/AWWA C110 and C111, Class 250 minimum, cement lined, with bituminous coating.

D. Fittings for cross linked polyethylene tubing shall be as required by the pipe manufacturer.

2.3 FLANGES

A. Flanges for copper piping systems shall be Class 150 wrought copper or cast brass conforming to ANSI B16.24.

B. Flange connections for valves and equipment shall match the rating and drilling of the valves and equipment furnished.

C. Gaskets shall be 1/16" thick ring type or full face non-asbestos material suitable for the temperatures and pressure application.

D. Flange bolting shall be carbon steel machine bolts or studs and hex nuts, ASTM A307, Grade B.

2.4 JOINTS

A. Joints in copper piping system shall be made using approved "lead-free" solder and flux as described herein and approved by all applicable codes and regulations. Surfaces to be soldered shall be cleaned bright by manual or mechanical means.

B. All joints shall be properly fluxed with a non-corrosive "lead-free" type flux manufactured to approved standards, Federal Specification QQ-S-517. Joints for copper piping systems for cold water 3" and smaller and hot water 2" and smaller shall be made using composition 95-5 tin-antimony solder. Composition 15% silver solder shall be used for all other piping sizes and for all underground joints.

C. Joints for cross linked polyethylene tubing shall be as required by the pipe manufacturer

2.5 SHOCK ABSORBERS

A. Furnish and install factory sealed shock absorbers conforming to Federal Specification WW-P-541 at locations shown on the drawings and/or as outlined by Plumbing Drainage Institute Standard WH-201. Josam, Precision, Jay R. Smith, Wade, Watts, Zurn or equivalent.

2.6 DOMESTIC HOT WATER GENERATING EQUIPMENT

A. Water heaters and associated auxiliary equipment shall be as specified on the equipment schedule on the drawings. Natural gas fired or electric domestic water heaters shall be as manufactured by Bock, Bradford-White, Lochinvar, P.V.I., Ruud, Rheem, A.O. Smith, State, or equivalent.

B. Furnish and install approved expansion tank on cold water make-up supply to hot water generating equipment as recommended by manufacturer or as shown on the drawings and specified in the plumbing equipment and fixture schedule on the drawings, Amtrol, Wilkins, or approved equal.

C. The Contractor shall provide the services of a qualified factory-trained representative to supervise hot water generation system start-up and instruct the Owner’s operating personnel for a minimum of eight (8) hours. A full one (1) year service warranty, including all parts and labor, shall be provided by the Contractor.

D. Natural gas fired domestic hot water boilers and water heater combustion flues, stack, breeching, and combustion air louvers, ducts, etc., shall be provided under Division 23.

2.7 VALVES

A. Valves other than automatic control valves are specified in Section 220523, Valves.

B. Automatic control valves shall be as specified in Section 230900, Facility Management System, except for automatic control valves furnished as a part of equipment packages, including hot water generating equipment, as specified on the equipment schedule.

2.8 PUMPS

A. Pumps shall be of the type and capacity listed in the equipment schedule. Pumps shall be selected so that the motors will not overload under any operating condition. Furnish one spare mechanical seal of each size required in conjunction with the pumps furnished under this Contract. All base mounted pumps shall have drain pans with tapped pipe connections and 3/4" drain line extended to floor drain. Pumps shall be installed so that they may be removed without the removal of the associated piping. All pumps for potable water applications shall have bronze or stainless steel body and trim.

B. Domestic water inline re-circulating pumps shall be as specified on the drawings and as manufactured by Armstrong, Bell & Gossett, Taco, Thrush, or equivalent.

2.9 WATER METER

A. See Division 33 for water meters.

2.10 BACKFLOW PROTECTION

A. All cross-contamination control shall be provided to ensure that no installation of the potable water supply piping system shall be made in a manner that will allow used, unclean, polluted, or contaminated water or substances to enter the domestic potable water system.

B. All backflow devices and assemblies shall be approved by the applicable Administration Authorities and shall be installed according to all applicable codes, regulations, and manufacturer's instructions. Installation shall allow for required access and clearance for required testing, maintenance, and repair.

C. Reduced pressure backflow preventer assembly shall be furnished and installed by the Contractor. Backflow preventer size and arrangement shall be as indicated on the drawings, and shall be as manufactured by Febco, Hersey, Beeco, Watts, Wilkins, or equivalent. All costs, fees, and permits required shall be secured and paid for by the Contractor, unless otherwise indicated.

D. See Division 33 for outdoor backflow protection.

E. See Section 230504 for backflow preventer required for make-up water connections to HVAC systems.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Piping installation shall conform to the requirements of Section 220500, Common Work Requirements for Plumbing and Section 220504, Pipe and Pipe Fittings for Plumbing. Installation of specialties shall conform to the requirements of Section 220505, Piping Specialties for plumbing.

B. Insulating Fittings: Insulating unions shall be furnished and installed at all connections between dissimilar metals.

C. Valves: Each water service main, branch main and branch to a group of two or more fixtures shall be valved. Stop valves shall be as specified under fixtures.

D. Flexible Connections: If the Contractor uses a pipe material other than copper to connect to the community water main, provide mechanical joints at the connection point and also either a swing joint or expansion joint at a point 5 ft. outside the building to prevent failure of piping caused by differential settling of building and piping systems. The expansion joint material shall be suitable for domestic water usage and compatible with the sterilization chemicals.

3.2 STERILIZATION

A. All new water piping shall be charged with a chlorine solution containing not less than 50 PPM available chlorine. The solution shall remain in the piping for a period of 24 hours, during which time valves shall be opened and closed to permit a small flow of the solution. At the end of 24 hours, the solution shall be tested and must contain a residual of at least 5-10 PPM chlorine. The system shall then be drained and flushed to provide satisfactory potable water before final connection is made to the existing distribution system.

B. The Contractor shall submit a sample of the water, after sterilization and flushing for testing by an approved laboratory. A copy of the acceptable test report shall be submitted to the Architect and Owner's Representative prior to substantial completion.

3.3 BACKFLOW PROTECTION

A. Protection: All plumbing fixtures, faucets with hose connections, and all other equipment having plumbing connections shall have their water supplies protected against back-siphonage.

B. Testing: Arrange for testing backflow devices as required by the local health authorities.

3.4 TESTS

A. All water piping, hot and cold, shall be made tight under a hydrostatic test pressure of 150 lbs. per square inch and maintained without pressure loss for a minimum of four (4) hours. No caulking of joints will be permitted. Any joint found to leak under this test shall be broken, remade and a new test applied.

END OF SECTION 22 1100

SECTION 22 1123 - FACILITY NATURAL GAS SYSTEM

PART 1 - GENERAL

1.1 REQUIREMENTS

A. Conform with applicable provisions of the General Conditions and Supplemental General Conditions.

1.2 RELATED SECTIONS

A. Section 220500, Common Work Requirements for Plumbing.

B. Section 220504, Pipe and Pipe Fittings for Plumbing.

C. Section 220505, Piping Specialties for Plumbing.

D. Section 220523, Valves for Plumbing.

E. Section 230900, Facility Management System.

F. Division 33 for onsite utilities.

1.3 SCOPE

A. Complete building natural gas piping system including meters, regulators, and miscellaneous accessories. This section shall include all work within the building and to a point approximately 5'-0" outside the building, or as otherwise indicated.

PART 2 - PRODUCTS

2.1 PIPING

A. Above ground pipe used for the installation, extension, alteration, and/or repair of any gas piping system shall be black steel pipe ASTM A53 Grade A or B, ERW or BW, standard wall, Schedule 40.

B. All underground gas piping shall be steel or polyethylene plastic piping as specified in Section 220523, Valves for Plumbing. All underground steel piping and fittings shall be protected from corrosion by approved coatings or wrapping materials as specified in Section 220504, Pipe and Pipe Fittings for Plumbing, and Section 226801, Outside Utilities, Plumbing.

2.2 FITTINGS

A. Fittings for steel piping 2" and smaller shall be either screwed or welded. Screwed fittings shall be Class 150 standard black malleable iron conforming to ANSI B16.3. Weld fittings shall be either standard weight steel butt-weld fittings conforming to ANSI B16.9, or forged steel socket-weld fittings, 2000 pound Schedule 40 conforming to ANSI B16.11.

B. Fittings for steel piping 2-1/2" and larger shall be standard weight steel butt-weld fittings conforming to ANSI B16.9.

2.3 FLANGES

A. Flanges for steel piping system shall be forged steel, weld neck, or slip-on, 1/16" raised face Class 150 flanges conforming to ANSI B16.5.

B. Flange connections for valves and equipment shall match the rating and drilling of the valves and equipment furnished.

C. Where specifically required by the application, black cast iron Class 125 standard threaded plain face companion flanges may be utilized for flanged connections in threaded piping systems.

D. Gaskets shall be 1/16" thick full face non-asbestos material suitable for the temperatures and pressure application.

E. Flange bolting shall be carbon steel machine bolts or studs and hex nuts, ASTM A307, Grade B.

2.4 VALVES

A. Valves shall be as specified in Section 220523, Valves for Plumbing.

B. Valves used in conjunction with gas piping shall be approved for the required service.

2.5 GAS METERS

A. Natural gas meters shall be furnished and installed by the natural gas utility company, unless otherwise indicated on the drawings. All required permits and fees shall be secured and paid for by the Contractor in accordance with Section 220500. Gas meter shall be the type and capacity required for the application and shall be located as indicated on the drawings and in accordance with utility company requirements and applicable codes and ordinances.

B. See Division 33 for natural gas meters.

2.6 NATURAL GAS REGULATOR

A. Natural gas regulator shall be furnished and installed with the gas meter by the utility company, set for the required gas leaving pressure shown on the drawings.

B. Natural gas appliance and equipment regulators for all gas fired equipment furnished and installed under Division 23 shall be furnished by the equipment manufacturer or supplier and sized for the system inlet pressure and the required appliance operating pressure.

C. See Division 33 for natural gas meter and regulator.

D. Natural gas regulators, as specified and shown on the drawings, shall be furnished and installed by the Contractor.

2.7 PIPING SUPPORTS

A. Natural gas piping installed on the building roof shall be supported by means of piping supports, especially designed to absorb thermal expansion and contraction of piping installed on built up and single ply membrane roofs. Wood blocks are not acceptable. Four inch and smaller gas piping shall be mounted on Erico Pyramid pipe supports or equivalent, pipe supports with a total weight not to exceed 100 pounds per pipe stand. Larger piping, and all piping requiring roller bearing action for pipe expansion, shall be mounted on Erico Pyramid RPS-H or equivalent, with a total weight not to exceed 1500 pounds per pipe collar support. Pipe support spacing shall be as recommended by manufacturer and as required by Code.

B. Piping hangers and supports shall be in accordance with Section 220504, Pipe and Pipe Fittings for Plumbing.

2.8 PAINTING

A. All natural gas piping installed outside the building exposed to the weather and/or exposed to view shall be field painted in accordance with the painting sections of this specification.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Piping installation shall conform to the requirements of Section 220500, Common Work Requirements for Plumbing, and Section 220504, Pipe and Pipe Fittings for Plumbing. Installation of specialties shall conform to the requirements of Section 220505, Piping Specialties for Plumbing.

B. Installation of piping and equipment shall be in accordance with applicable codes and regulations, including Uniform Plumbing Code and Uniform Mechanical Code, and NFPA No. 54, National Fuel Gas code.

C. No gas piping shall be installed in or on the ground under any building or structure, and all exposed gas piping shall be at least 6-inches above grade. Ferrous gas piping installed underground in exterior locations shall be protected for corrosion as specified herein and in Section 220504, Pipe and Pipe Fittings for Plumbing.

D. Gas piping supplying the building or facility shall be provided with a shut-off valve located outside the building and readily accessible. Where gas piping supplies multiple buildings or facilities, each building shall be provided with a shut-off valve as described herein.

3.2 EQUIPMENT AND APPLIANCE CONNECTIONS

A. All gas fired equipment and appliances shall be connected to the gas piping system in an approved manner and shall be furnished with a shut-off valve installed ahead of the unit. Connections shall in no case be less than the unit inlet connection size and shall be rigidly connected, except as otherwise shown on the drawings and allowed by codes and regulations.

3.3 DRIPS

A. Accessible capped drip pockets shall be furnished at low points in piping system, connections to appliances and equipment, and other locations where condensation may tend to collect.

3.4 VENTS

A. All gas regulators and other required devices installed within the building shall be vented to the outside of the building in accordance with manufacturer's requirements, codes, and regulations.

3.5 TESTS

A. All gas piping shall be pressure tested using air, CO_2, or nitrogen in accordance with the applicable codes and regulations, including Uniform Plumbing and Mechanical Code and NFPA No. 54.

END OF SECTION 22 1123

SECTION 22 1316 - SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

1.1 REQUIREMENTS

A. Conform with applicable provisions of the General Conditions and Special Provisions.

B. Furnish and install all concrete, grout, and other required materials to fill all blockouts and/or sleeves left open for this Contractor's convenience or for the installation of this work.

1.2 RELATED SECTIONS

A. Section 220500, Common Work Requirements for Plumbing.

B. Section 220504, Pipe and Pipe Fittings for Plumbing.

C. Section 220700, Plumbing Insulation.

D. Division 33 for Onsite Utilities Plumbing.

E. Section 230900, Facility Management System.

1.3 SCOPE

A. Complete soil, waste, and vent system, and associated miscellaneous accessories. This section shall include all work within the building to a point approximately 5'-0" outside the building, or as otherwise indicated.

B. Coordinate with Division 33 site utility drawings and specifications.

C. Plumbing equipment drains.

PART 2 - PRODUCTS

2.1 PIPING

A. Soil, waste and vent pipe and fittings below slab:

1. Hubless cast iron, coated on both sides, conforming to ASTM A 888 and CISPI 301.
2. Service weight, hub-and-spigot cast iron, coated on both sides, conforming to ASTM A 74.
3. Schedule 40, solid wall, polyvinyl chloride (PVC) with a cell class of 12454 or 12364 per ASTM D 1784, iron pipe size (IPS) conforming to ASTM 1785 and ASTM D 2665. Cast iron pipe and fittings shall be used on all waste piping subject to waste water temperatures that exceed 120° F.

B. Soil, waste and vent pipe and fittings above grade:

1. Hubless cast iron, coated on both sides, conforming to ASTM A 888 and CISPI 301.
2. Service weight, hub-and-spigot cast iron, coated on both sides, conforming to ASTM A 74.

2.2 FITTINGS

A. Fittings for cast iron sanitary soil, waste and vent piping system shall be service weight or no-hub cast iron drainage pattern conforming to ASTM C564. Fittings shall be provided to match the required piping system.

B. No-Hub pipe fittings shall comply with CISPI Standard 301 and shall be marked with CISPI Label.

2.3 JOINTS

A. Joints for cast iron pipe and fittings shall be suitable to match the required piping system and shall be double seal compression-type molded neoprene gaskets conforming to ASTM C-564 Standards, and suitable for the class of pipe being jointed, with adhesive type joint lubricant, Tyler "LUBRI/FAST" or equivalent. No-hub coupling shall be minimum four (4) band type with neoprene gasket material conforming to ASTM C-564, and 0.008-inch minimum, Type 304 stainless steel shear ring. Couplings shall be Tyler "Wide Body", Huskey Series 4000, Clamp-All, Mission Heavy Weight, Ideal, or equivalent.

2.4 PLUMBING EQUIPMENT DRAINS

A. Equipment drain lines shall be either Schedule 40 galvanized steel pipe with galvanized malleable iron fittings or Type L copper tubing with wrought solder fittings. Provide a dielectric union at all connections between ferrous to copper materials.

2.5 DRAINS

A. Floor drains, floor sinks, and interceptors shall be Josam, Rockford, Jay R. Smith, Wade, Watts, Zurn, Mifab, or equivalent, as specified on the drawings, and compatible with the required piping systems.

2.6 TRAPS AND TAILPIECES

A. Unless otherwise specified, traps shall be copper-alloy adjustable tube type with slip joint inlet and swivel, not less than 17 gauge and without cleanout. Inlets shall have rubber washer and copper alloy nuts for slip joints above the discharge level and swivel joints below the discharge level, metal to metal or metal to plastic type as required for the application. Outlet shall be threaded or socket for solder joint connection as required by the application. Tailpiece shall be copper-alloy to match P-trap. Furnish cast brass wall escutcheon at waste penetration through walls. P-traps, tailpieces, escutcheon, and all piping for above floor exposed installations, including installation within

cabinets and casework shall be chrome plated. Underground P-traps shall be coated cast iron as required by the application.

B. Traps and associated trim shall be furnished by the plumbing fixture manufacturer as specified in Section 224000 and in the Fixture Schedule on the drawings, or shall be as manufactured by Dearborn, EBC, McGuire, T & S Brass, or equivalent.

C. Traps for acid resistant piping systems shall be compatible material for required piping system.

2.7 LINT INTERCEPTORS

A. Lint interceptors of the sizes indicated shall be of reinforced concrete, or precast concrete construction or equivalent capacity commercially available steel lint interceptor with removable three-section, 3/8-inch checker-plate cover, and shall be installed outside the building. Steel lint interceptor shall be installed in a concrete pit and shall be epoxy-coated to resist corrosion as recommended by the manufacturer. Interceptors shall be tested and rated in accordance with Plumbing and Drainage Institute PDI-G101. Concrete shall have 3,000 PSI minimum compressive strength at 28 days.

2.8 CLEANOUTS

A. Cleanouts shall be as manufactured by Zurn, Jay R. Smith, Watts, Wade, or Josam, and shall be of the same size as the pipe, except that cleanout plugs larger than 4 inches will not be required. Cleanouts installed in connection with cast iron soil pipe shall consist of a long sweep, quarter-bend or one or two eighth bends extended to an easily accessible place, or as indicated on the drawings. A standard cleanout fitting, Zurn No. ZN-1400-ZB, with polished bronze top shall be caulked into the hub of the fitting and finished flush with the floor. Heavy duty cleanouts shall be Zurn Z-1474, with integral anchor flanges. Where cleanouts in connection with threaded pipe are shown and are accessible, they shall be cast iron drainage T-pattern, 90 degree branch fittings with square head brass screw plugs of the same size as the pipe up to and including 4 inches. Wall cleanouts in finished areas shall be Zurn No. Z-1460-8 with polished stainless steel or chrome plated metal cover.

B. Install cover flush with grade (outside) to avoid tripping hazard.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Piping installation shall conform to the requirements of Section 220500, Common Work Requirements for plumbing, and Section 220504, Pipe and Pipe Fittings for Plumbing. Installation of specialties shall conform to the requirements of Section 220505, Piping Specialties.

B. All soil, waste, and vent piping shall be properly graded and installed in strict accordance with all applicable codes and requirements.

C. Make all changes in direction of drainage piping by use of 45 degree wyes, long turn tee wyes, long

sweep quarter bends, sixth, eighth or sixteenth bends. Short turn sanitary tees permissible on horizontal to vertical where space conditions require.

3.2 FLASHINGS

A. Flashing for piping through built-up roofing with lead flashing, weight of not less than four pounds per square foot, extending at least 12" in all directions under roofing and up pipe. Cap flash pipe and turn down inside 1" approximately. Run all pipes extending through roof prior to roof installation. Flashing shall be two-piece type, base and cap flashing.

B. Flash piping through the membrane roofing systems with premolded pipe seal elastomeric flashing and sealants that are compatible with EPDM single ply membrane. The flashing material and installation procedure shall be in accordance with the roofing manufacturer's recommendations.

3.3 DRAINS

A. All floor drains, area drains, and floor sinks shall be installed with grates square with building lines and with the top of grates installed level with adjacent finished floor.

B. The Contractor shall extend drain lines from all equipment requiring drainage, relief valves, and drain pans to the nearest floor drain or floor sink, and shall terminate indirectly with a minimum clearance of one (1) inch or as otherwise required by applicable codes and standards. Relief valve drain lines shall be extended to the nearest floor drain and shall be equal in size to relief valve outlet port.

3.4 TESTS

A. The sanitary soil waste and vent system and condensate drain system shall be tested by filling system with water. System shall remain filled with no loss of water for a minimum of 2 hours. The system water test shall be applied to the drainage and vent systems either in its entirety or in sections. Preliminary testing shall be accomplished as necessary prior to final test.

B. If applied to the entire system, all openings in the piping shall be tightly closed, except the highest opening, and the system filled with water to point of overflow. If the system is tested in sections, each opening shall be tightly plugged except the highest opening of the section under test, and each section shall be filled with water, but no section shall be tested with less than ten (10) feet of water. In testing successive sections, at least the upper ten (10) feet of the next preceding section shall be tested, so that no joint or pipe in the building (except the uppermost ten feet) of the system shall have been submitted to a test of less than a ten (10) foot head of water. The system shall then be tight at all points.

END OF SECTION 22 1316

SECTION 22 1400 - FACILITY ROOF AND AREA DRAINAGE

PART 1 - GENERAL

1.1 REQUIREMENTS

A. Conform with the applicable provisions of the General Conditions and Special Provisions.

1.2 RELATED SECTIONS

A. Section 220500, Common Work Requirements for Plumbing.

B. Section 220504, Pipe and Pipe Fittings for Plumbing.

C. Section 220700, Plumbing Insulation.

D. Division 33 for onsite plumbing utilities.

1.3 SCOPE

A. Complete roof drainage, overflow roof drainage and area drainage system and associated miscellaneous accessories. This section shall include all work within the building and to a point approximately 5'-0" outside the building, or as otherwise indicated.

B. Coordinate with Division 33 site utility drawings and specifications.

PART 2 - PRODUCTS

2.1 PIPING

A. Pipe, fittings and couplings below grade or slab-on-grade shall be service weight cast iron no hub pipe, coated inside and outside, conforming to ASTM A-74 and 87 Standards.

B. Pipe, fittings and couplings above slab on grade shall be either service weight cast iron no hub pipe, coated inside and outside, conforming to ASTM A-74 and 87 Standards,

C. No-hub cast iron pipe shall conform to CISPI Standard 301 and shall be marked with CISPI Label.

D. All above and/or below ground cast iron pipe and/or fittings shall be marked with the trademark of the Cast Iron Soil Pipe Institute **,** or have the prior written approval of Bridgers & Paxton Consulting Engineers.

2.2 FITTINGS

A. Fittings for cast iron pipe shall be service weight or no-hub cast iron drainage pattern, conforming to ASTM C564, coated for underground installation.

2.3 JOINTS

A. Joints for cast iron pipe and fittings shall be suitable to match the required piping system and shall be double seal compression-type molded neoprene gaskets conforming to ASTM C-564 Standards, and suitable for the class of pipe being jointed, with adhesive type joint lubricant, Tyler "LUBRI/FAST" or equivalent. No-hub couplings shall be minimum four (4) band type with neoprene gasket material, conforming to ASTM 564, and 0.008-inch minimum, Type 304 stainless steel shear ring. Couplings shall be Tyler "Wide Body," Husky Series 4000, Clamp-All, Mission Heavy Weight, Ideal, or equivalent.

2.4 DRAINS

A. Roof drains, overflow roof drains, and area drains shall be Josam, J. R. Smith, Watts, Wade, Zurn, Froet, Mifab, or equivalent as specified on the drawings and compatible with the required piping system. Drains shall be suitable for the required building construction system and shall be furnished complete with all extensions, receptors, flashings, and accessories required for the complete water-proof installation.

2.5 CLEANOUTS

A. Cleanouts shall be as manufactured by Josam, J. R. Smith, Wade, Watts, Zurn, Mifab, or equivalent, and shall be of the same size as the pipe, except that cleanout plugs larger than 4 inches will not be required. Cleanouts installed in connection with cast iron soil pipe shall consist of a long sweep, quarter-bend or one or two eighth bends extended to an easily accessible place, or as indicated on the drawings. A standard cleanout fitting, Zurn No. ZN-1400-ZB, with polished bronze top shall be caulked into the hub of the fitting and finished flush with the floor. Heavy duty cleanouts shall be Zurn Z-1474, with integral anchor flanges. Where cleanouts in connection with threaded pipe are shown and are accessible, they shall be cast iron drainage T-pattern, 90-degree branch fittings with square head brass screw plugs of the same size as the pipe up to and including 4 inches. Wall cleanouts in finished areas shall be Zurn No. Z-1460-8 with polished stainless steel or chrome plated metal cover.

2.6 ACCESSORIES

A. Refer to Section 221316, Sanitary Waste & Vent Piping, for roof flashing requirements.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Piping installation shall conform to the requirements of Section 220500, Common Work Requirements for Plumbing, and Section 220504, Pipe and Pipe Fittings for plumbing. Installation of specialties shall conform to the requirements of Section 220505, Piping Specialties for Plumbing.

B. Roof drainage and area drainage piping shall be properly graded and installed in strict accordance with all applicable codes and requirements. All turns and fittings shall be supported same as for waste and vent piping as specified in Section 221300.

3.2 AREA DRAINS

A. All area drains shall be installed with grates square with building lines, and with the top of grates installed level with the adjacent finish grade level.

3.3 TESTS

A. The roof drainage and area drainage system shall be tested by filling system with water. System shall remain filled with no loss of water for a minimum of 2 hours. The system water test shall be applied to the systems either in its entirety or in sections. Preliminary testing shall be accomplished as necessary prior to final test.

B. If applied to the entire system, all openings in the piping shall be tightly closed, except the highest opening, and the system filled with water to point of overflow. If the system is tested in sections, each opening shall be tightly plugged except the highest opening of the section under test, and each section shall be filled with water, but no section shall be tested with less than a ten (10) foot of water. In testing successive sections, at least the upper ten (10) feet of the next preceding section shall be tested, so that no joint or pipe in the building (except the uppermost ten feet) of the system shall have been submitted to a test of less than a ten (10) foot head of water. The system shall then be tight at all points.

END OF SECTION 22 1400

SECTION 22 4000 - PLUMBING FIXTURES AND TRIM

PART 1 - GENERAL

1.1 REQUIREMENTS

A. Conform with applicable provisions of the General Conditions, Supplemental General Conditions and the General Requirements.

B. Lead Ban: All systems and system components, pipe, fittings, and fixtures delivering water for human consumption shall be lead free.

1. Any product designed for dispensing potable water shall meet both the NSF 61 and NSF 372 test standards via third-party testing and certification.
2. Lead free refers to <0.25% weighted average lead content in relation to wetted surface of pipe, fittings, and fixtures in systems delivering water for human consumption, and solder and flux which does not contain more than 0.2% lead.

1.2 RELATED SECTIONS

A. Section 220500, Common Work Requirements for Plumbing.

B. Section 220504, Pipe and Pipe Fittings for Plumbing.

C. Section 221100, Domestic Water Piping.

D. Section 221316, Sanitary Waste and Vent Piping.

PART 2 - PRODUCTS

2.1 FIXTURES AND EQUIPMENT

A. Vitreous china and enameled cast iron fixtures by American Standard, Kohler, Sloan, Zurn, Mansfield, Toto, or equivalent as listed and described in the plumbing fixture schedule on the drawings. All vitreous china and enameled cast iron fixtures shall be white, unless otherwise indicated on the drawings. The material used for plumbing fixtures shall be of non-absorptive, acid-resistant vitreous china, enameled cast iron or stainless steel, and free from all imperfections. Each water service main, branch main, riser and branch to a group of fixtures shall be valved or as otherwise shown on the drawings to provide more stringent requirements. Stop valves shall be provided at each fixture. One piece chrome plated escutcheons shall be installed on all water piping and trap connections at walls or base cabinets. All exposed connecting piping and material shall be chrome plated.

B. Handicap accessible lavatories and counter mounted sinks shall have exposed supply and waste services insulated with rigid, molded insulation kits as manufactured by T.C.I. "Skal-Gard", Brocar "Trap Wrap", True-Bro "Handi Lav-Guard", McGuire "Prowrap", or equivalent. Provide off-set tail piece fittings on all handicap accessible laboratories and sinks as required.

C. Flush valves shall be low water consumption type as specified on drawings. Valves shall be diaphragm or piston type, with metal oscillating non-hold open handle, screw driver back check angle stop assembly with cap, adjustable tailpiece, vacuum breaker flush connection, and spud couplings as required for wall and fixture rough-in. Exposed flush valves shall be fully chrome plated, with chrome plated supply pipe cover. Flush valves shall be Sloan Royal, or Sloan Regal.

D. Closet seats shall be furnished for water closets as specified on the Plumbing Fixture Schedule on the drawings. Closet seats shall be white unless otherwise required to match water closet. All closet seats shall be of smooth non-absorbent material and shall be properly sized for the water closet bowl type. All closet seats for fixtures for public use shall be open-front type without cover. Water closet seats provided for handicapped fixtures shall meet all handicapped requirements. Hinges, posts, nuts, and pintles shall be of a 300 series stainless steel construction. Water closet seats shall be furnished by the plumbing fixture manufacturer as specified on the Fixture Schedule on the drawings, or shall be as manufactured by Bemis, Beneke, Centoco, Church, Olsonite, Sperzel, or equivalent.

E. Floor mounted mop sinks shall be as specified on the Plumbing Fixture Schedule on the drawings, molded stone or terrazzo, size and arrangement as shown on the drawings, as manufactured by Acorn, Centoco, Designer's Choice, Fiat, Mustee, Stern-Williams, Zurn, or equivalent.

F. Stainless steel sinks shall be as specified on the Plumbing Fixture Schedule on the drawings and as manufactured by Kohler, American Standard, Elkay, Just, Advance Tabco, Moen, Designers Choice, or equivalent. Countertop sinks indicated within the Architectural drawings to be handicap-compliant shall have an off-centered drain opening and a maximum sink depth of 7-inches. All sink basins shall have a center-rear outlet unless noted otherwise.

G. Electric water coolers (EWC) and drinking fountains shall be as specified on the Plumbing Fixture Schedule on the drawings and as manufactured by Elkay, Haws, Halsey Taylor, Oasis, Westinghouse, Sunroc, Acorn Aqua, or equivalent.

H. Hose bibbs and wall hydrants shall be as specified on the Plumbing Fixture Schedule on the drawings and as manufactured by Zurn, Jay R. Smith, Wade, Woodford, Acorn, Chicago, T&S Brass, Watts, or equivalent. Handles, if specified shall be constructed of metal or brass and finished to match valve unit.

I. Shower valves and mixing valves shall be as specified on the Plumbing Fixture Schedule on the drawings, and as manufactured by Powers, Leonard, Lawler, Speakman, Symmons, Bradley, or equivalent.

J. Emergency fixtures including showers and eyewash shall be as specified on the Plumbing Fixture Schedule on the drawing and as manufactured by Bradley, Chicago, Haws, Speakman, Western, Guardian, Acorn Safety, or equivalent.

2.2 FAUCETS

A. Plumbing fixture faucets shall be brass construction and fully chrome plated, unless special finish is specified on the Plumbing Fixture Schedule on the drawings. Faucets shall be furnished complete with all accessories required for the necessary application, including aerators, handles, spouts, and operating cartridges. Contractor shall coordinate exact faucet requirements with required fixture drilling and water and waste rough-in. Faucets for handicapped fixtures shall meet all handicapped and ADA requirements, including a maximum of five (5) pounds of force to activate controls and adjustable metering faucet water flow duration of ten (10) seconds, minimum. Single hole faucets shall have anti-clocking pin to prevent rotation of valve body.

B. Plumbing fixture faucets shall be furnished by the fixture manufacturer as specified in the Plumbing Fixture Specification on the drawings and Paragraph 2.1 herein, or shall be as manufactured by Chicago, Commercial Delta, Commercial Moen, Speakman, T&S Brass, Zurn, or equivalent, and shall be commercial grade.

2.3 PLUMBING FIXTURE TRIM

A. Plumbing fixture trim including P-traps, supplies, and strainers shall be furnished by the fixture manufacturer as specified in the Plumbing Fixture Specification on the drawings and Paragraph 2.1 herein, or shall be as furnished by Chicago, Brass Craft, McGuire, T&S Brass, EBC, Zurn, or equivalent.

B. Unless otherwise specified, traps shall be copper-alloy adjustable tube-type with slip joint inlet and swivel, not less than 17 gauge and without cleanout. Inlets shall have rubber washer and copper alloy nuts for slip joints above the discharge level and swivel joints below the discharge level, metal-to-metal or metal-to-plastic type as required for the application. Outlet shall be threaded or socket for solder joint connection as required by the application. Tailpiece shall be copper-alloy to match P-trap. Furnish brass or copper wall escutcheon at waste penetration through walls. P-traps, tailpieces, escutcheon, and all piping for above floor exposed installations, including installation within cabinets and casework shall be chrome plated.

C. Fixture supplies, strainers, and trim shall be brass construction. Supplies shall be commercial grade, quarter-turn all brass ball valves, plastic stems and handles are not acceptable. Furnish supply with loose key unless otherwise specified. Supply pipe shall be 3/8" O.D., with smooth (non-corrugated) flexible copper riser and wall escutcheon. Supply assembly shall be completely chrome plated for all exposed installations, including installation within cabinets and casework. Strainers and other miscellaneous fixture trim shall be furnished as required for the proper installation and shall be chrome plated to match faucets, unless special finish is required.

PART 3 - EXECUTION

3.1 INSTALLATION

A. The Contractor shall provide all necessary supports and connection materials and trim for plumbing fixtures as required to assure a complete properly installed and operating system. Installation shall be in accordance with manufacturer's recommendations and with International Building Code and Uniform] Plumbing Code requirements. The Contractor shall caulk fixtures to the adjacent wall, floor and countertop construction with non-shrink, mildew resistance caulking material.

B. Fixture mounting height shall conform to the ADA Accessibility Requirements and coordinated with the Architectural drawings.

1. ADA required Water Closet shall be mounted with seat 17" – 19" above finished floor.
2. ADA required Urinal shall be mounted at a maximum of 17" top of rim to finished floor.
3. ADA required Lavatory to be mounted with the rim or counter surface no higher than 34" above finished floor.
4. ADA required shower controls shall be located from 38" minimum to 48" maximum height above the shower floor.
5. ADA required Bathtub controls shall be located maximum of 48" above bottom of tub surface.
6. ADA required Sinks shall be mounted with counter or rim no higher than 34" above finished floor.
7. ADA required Drinking Fountains or Water Coolers spouts shall be no higher than 36" measured from the floor or ground surface to the spout outlet.

3.2 EQUIPMENT/FIXTURE SUPPORT

A. Furnish and install all "back-up" materials for fixtures and accessories, or as otherwise required by the equipment schedule to properly support and provide a sturdy installation.

3.3 FIXTURE CARRIERS

A. Fixture carriers shall be provided for all wall hung plumbing fixtures, including urinals, lavatories, sinks, etc., as manufactured by Josam, Jay R. Smith, Watts, Wade, Zurn, MiFab, or equivalent. Carriers shall be bolted to the floor using all of the support bolts recommended by the manufacturer. Where the water closet nipple and studs extend beyond the maximum carrier recommended length, provide additional carrier support as recommended by manufacturer.

B. Wall hung urinals shall be provided with floor mounted fixture carrier complete with upper and lower fixture support plates as required to match fixture installation requirements.

C. Wall hung lavatories and sinks shall be provided with floor mounted concealed arm type chair carriers, single or double (back-to-back) units as required for the fixture installation and arrangement.

D. Contractor shall be responsible to provide the proper arrangement and selection of fixture carriers required for fully concealed installation in the available plumbing chase and/or wall construction.

3.4 EQUIPMENT FURNISHED BY OTHERS

A. The Contractor shall furnish and install complete rough-in and connections, including stop valves on all supply piping for all mechanical services required for equipment furnished and installed under other sections of this specification, and for all owner-furnished equipment.

B. Types of equipment in this category shall include but not be limited to the following: kitchen equipment, shop equipment, hospital and laboratory casework, medical equipment, etc. The Contractor shall provide all pipe fittings, unions, traps, connecting wastes, valves, cocks, regulators, pressure reducing valves, flexible connectors, etc., as required for the services to each piece of equipment.

C. Installation and setting of equipment and fixtures furnished under other Sections of this Specification will not be provided under Division 22 of this Specification, unless otherwise indicated.

3.5 FIELD MEASUREMENTS AND COORDINATION

A. Exact location and rough-in requirements shall be carefully coordinated. Contractor shall refer to drawings and specifications, and shall check manufacturer's data, shop drawings and rough-in drawing submitted under Division 22 and other Divisions of this specification and make all field measurements to the extent necessary to ensure his understanding of the work required to provide for complete rough-in installation.

3.6 CLEANING

A. All fixtures shall be thoroughly cleaned before final acceptance of the work.

END OF SECTION 22 4000

SECTION 22 6801 – ONSITE NATURAL GAS

PART 1 - GENERAL

1.1 REQUIREMENTS

A. Conform with the applicable provisions of the General Conditions and Supplemental Conditions.

B. Lead Ban: All systems and system components, pipe, fittings, and fixtures delivering water for human consumption shall be lead free.

1. Any product designed for dispensing potable water shall meet both the NSF 61 and NSF 372 test standards via third-party testing and certification.
2. Lead free refers to <0.25% weighted average lead content in relation to wetted surface of pipe, fittings, and fixtures in systems delivering water for human consumption, and solder and flux which does not contain more than 0.2% lead.

C. Soldered joints below grade shall be made using Sil-Fos or Phos-Copper.

1.2 SCOPE

A. Natural Gas System.

1.3 RELATED SECTIONS

A. Section 220500, Common Work Requirements for Plumbing.

B. Section 220504, Pipe and Pipe Fittings for Plumbing.

C. Section 220505, Piping Specialties for Plumbing.

D. Section 220523, Valves for Plumbing.

E. Section 221100, Domestic Water Piping.

F. Section 221316, Sanitary Waste and Vent Piping.

G. Section 221400, Facility Roof and Area Drainage.

H. Section 221123, Facility Natural Gas System.

1.4 GENERAL REQUIREMENTS

A. Excavation and backfilling shall conform to the requirements of Division 33 and Section 220503 on Excavation, Trenching, and Backfilling for Utilities. Work covered by this section will not be accepted until backfilling connected with the work has been completed satisfactorily. Any section of the utilities that is found defective in material, alignment, grade, or joints before acceptance shall be corrected. All pipe and accessories shall be of new and unused material. The full length of each section of pipe shall rest solidly upon the pipe bed, with recesses excavated to accommodate the bells and joints. Any pipe that has the grade or joint disturbed after laying shall be taken up and relaid. The interior of the pipe shall be thoroughly cleaned of all foreign matter before being lowered into the trench and shall be kept clean during laying operations by means of plugs or other approved methods. The pipe shall not be laid in water, or when trench or weather conditions are unsuitable for the work. Water shall be kept out of the trench, until the joints are completed. When work is not in progress, open ends of pipe and fittings shall be securely closed so that no trench water, earth or other substance will enter the pipes or fittings. Any section of pipe found to be defective before or after laying shall be replaced with new pipe without additional expense to the Owner. Minimum depth of trench for water piping shall provide 42 inches of cover over the pipe. Minimum depth of trench for gas shall be 30 inches for plastic or 24" for steel.

1.5 UNDERGROUND PIPING IDENTIFICATION

A. The location of each underground piping system shall be marked using a continuous, pre-printed, colored plastic ribbon tracer tape, as specified in Section 22 0500. Additionally, non-metallic underground piping shall be provided with a special detection type tape conforming to applicable Code requirements.

PART 2 - PRODUCTS

2.1 NATURAL GAS SYSTEM

A. The gas distribution system is intended for the distribution of natural gas and the materials, appurtenances and workmanship used in this system shall be suitable and approved for natural gas service. Any section of the gas distribution system that is found defective in materials or workmanship before acceptance shall be corrected.

B. Plastic pipe welders shall be qualified in heat fusion techniques in accordance with Federal Standard 49 CFR, Part 192.285, and shall have in their possession evidence of such qualifications. Welders for steel piping shall be certified in accordance with the provision contained within Section 220500.

C. Contractor shall have a written procedure approved by the State of New Mexico for installation of polyethylene gas piping. Submit evidence of qualifications prior to commencing work on the natural gas piping system.

D. The gas system shall conform to the applicable requirements of all State of New Mexico codes and ordinances including the Uniform Plumbing Code, and Uniform Mechanical Code, NFPA No. 54, and to the rules and regulations of the Utility Company supplying the gas, including the U.S. Department of Transportation "Pipeline Safety Regulations, Part 192, CFR-49.

E. In shipping, delivering, and installing, pipe and accessories shall be handled in such manner as to ensure a sound, undamaged condition. Particular care shall be taken not to injure pipe and pipe coatings. No pipe or material of any kind shall be placed inside another pipe or fitting after the coating has been applied. Coated and wrapped steel pipe shall be handled in conformance with the American Water Works Association Specification C204.

F. Submit manufacturer's catalog data and installation procedures on pipe, fittings, valves, risers and other material to be incorporated into construction for the natural gas distribution system.

G. Piping: Provide any of the following optional piping systems unless shown otherwise on the plans. All pipe and accessories shall be new and unused.

1. Polyethylene Plastic Pipe: Underground natural gas piping distribution system shall be black or orange polyethylene plastic natural gas distribution pipe with heat fusion joints. Pipe shall be PE-2406, PE-3406, or PE-3408 in accordance with ASTM D2513, as manufactured by POLY-ARK, PLEXCO, Poly-Pipe or equivalent. Contractor shall use the same type and designation of piping throughout the project. Piping shall have approved tracing system (copper 18 gauge wire, or tape) and shall be installed in compliance with all requirements of Authority in jurisdiction.

    a. Risers: Anodeless risers shall consist of polyethylene encased steel pipe sweeps integrally connected to appropriately sized polyethylene pipe at the bury end with threaded IPS connections at the exposed end. Risers shall be as manufactured by Wayne or equivalent. Above ground piping and fittings used to connect to building services shall be black steel, Schedule 40, as specified in Division 23, Section 23 07 00. Incidental below-ground pipe and fittings shall conform to the above specifications and shall be coated and wrapped.
    b. Valves and Valve Boxes: Natural gas main valves shall be plastic valves of the size specified suitable for gas service, compatible with the polyethylene pipe utilized, and conforming to ANSI, Bl6.40, with a minimum working pressure of 125 PSIG, Rockwell or equivalent. Valves shall be installed in cast iron valve box and cover as specified under section for Water Systems, and shall be marked with "GAS" on cover.

2. Natural gas meters shall be furnished and installed by the natural gas utility company, unless otherwise indicated on the drawings. All required permits and fees shall be secured and paid for by the Contractor in accordance with Section 22 0500, Common Work Requirements for Plumbing.
3. See Division 33 for any additional natural gas meters requirements.

H. Natural Gas Regulator:

1. Natural gas regulators, as specified on the plumbing equipment and fixture schedule and as shown on the drawings, shall be furnished and installed by the Contractor.

PART 3 - EXECUTION

3.1 GENERAL

A. Install utility service lines to a point of connection to the building service lines, approximately five (5) feet outside of the building, and make connections to the building service lines in an approved manner. See the applicable specification sections for requirements associated with the building service lines. All non-metallic piping systems installed under this section of the specification shall terminate approximately five (5) feet from the building and piping system materials approved for installation within the building and specified in the applicable sections shall be provided for connection to the underground utility systems and extension to the building.

B. Installation of utility piping distribution systems including natural gas systems shall be installed as specified herein and in strict accordance with manufacturer's recommendations.

C. In shipping, delivery, and installation pipe and accessories shall be handled in such manner as to ensure sound undamaged condition.

D. Cutting of pipe shall be done in a neat and workmanlike manner without damage to the pipe. Unless otherwise authorized. Cutting shall be done by means of an approved type of mechanical cutter. Wheel cutters shall be used whenever possible.

E. Where connections are made between new work and existing mains, the connections shall be made by using specials and fittings to suit the actual conditions. Standard methods are available for making connections to various types of pipe, either under pressure or in the dewatered condition.

F. Pipe passing through walls of vaults, pits, and structures shall be provided with ductile-iron or Schedule 40 steel wall sleeves. Annular space between walls and sleeves shall be filled with rich cement mortar. Annular space between pipe and sleeves shall be sealed in accordance with requirements contained in Section 220504.

G. Flanged pipe shall only be installed above ground or within vaults, pits, or structures only.

3.2 INSTALLATION

A. Piping installation shall conform to the requirements of Section 220500, Common Work Requirements for Plumbing, and Section 220504, Pipe and Pipe Fittings for Plumbing. Installation of specialties shall conform to the requirements of Section 220505, Piping Specialties for Plumbing.

B. Installation of piping and equipment shall be in accordance with applicable codes and regulations, including Uniform Plumbing Code and Uniform Mechanical Code, and NFPA No. 54, National Fuel Gas Code.

C. Water lines shall not be laid in the same trench with sewer lines, gas lines, fuel lines, or electric systems.

D. Copper tubing shall not be installed in the same trench with ferrous piping materials. Where copper tubing crosses any ferrous piping material, a minimum vertical separation of 12 inches must be maintained between pipes.

E. Where utility piping systems are required to be installed within three (3) feet of existing or new structures, the pipe shall be of a material approved for installation within the building or shall be installed within a sleeve of rigid conduit to a point 10'-0" on either side of the structure. Care shall be exercised and proper precautions taken during installation of the pipe and sleeve to assure that there will be no damage to the structure and no settlement or movement of foundations or footings. Any damage occurring as a result of the Contractor's operation shall be corrected and all costs connected therewith shall be borne by the Contractor.

3.3 JOINT DEFLECTION

A. Plastic Pipe: Maximum offset in alignment between adjacent pipe joints shall be as recommended by the manufacturer, but in no case shall it exceed five (5) degrees.

3.4 NATURAL GAS SYSTEM

A. Pipe Laying:

1. Lines may conform to the surface profile but should be graded as uniformly as practicable between pronounced high and low points. Pipe shall be laid on firm soil for the full length, and where the trench has been excavated below grade, either inadvertently or purposely, it shall be backfilled with suitable material and thoroughly tamped so as to provide full length bearing. Laying the pipe on blocks to produce uniform grade shall not be done. The pipe shall be clean inside before it is lowered in the trench and shall be maintained free of water, soil, and all other foreign matter that might injure or obstruct the operation of valves, regulators, burners, or other equipment. All openings to the pipe shall be closed by suitable means at all times except as the actual progress of the work may require. Stub ends and fittings installed for future connections shall be closed with plugs or caps. Minor change in line or grade of steel pipe, which can be accomplished through flexibility of the pipe without producing permanent deformation or overstressing the joints, may be made when approved. Changes in line or grade which exceed the limitations specified above shall be made with suitable fittings.
2. Install gas piping in separate trench with minimum horizontal clearance of thirty-six (36) inches from other utilities. Maintain twelve (12) inches vertical clearance at utility crossings. Maintain minimum cover to finish grade of 24 inches for steel or 30 inches for plastic piping. Snake plastic pipe laterally in trench to accommodate expansion and contraction of materials.

B. Jointing:

1. All joints in steel gas distribution system shall be made by the metal arc-welding process or oxyacetylene welding process in conformance with the American Standards Association Code B31.1, and in accordance with applicable requirements contained in Sections 220500 and 220504.

2. Joints for polyethylene natural gas piping distribution system shall be heat fusion welded or mechanical coupling installed in strict accordance with manufacturer's recommendations by qualified and certified plastic pipe installers. Foundation and bedding for plastic piping systems shall be in accordance with installation recommendations by the manufacturer.

C. Building Service Connections: Natural gas service connections to each individual building shall be made by means of an approved anodeless riser and steel pipe and fittings. All connections to buildings and service regulator piping shall be above ground, see Division 23, Section 221123.

3.5 TESTING OF NATURAL GAS

A. All gas piping shall be pressure tested using air, CO_2, or nitrogen in accordance with the applicable codes and regulations, including Uniform Plumbing and Mechanical Code and NFPA No. 54. Plastic piping shall be tested in accordance with 49 CFR, Part 192.513, except that these pressure shall be at least 60 PSIG.

B. All pipe joints in piping system shall be exposed until they are tested. Piping between joints may be backfilled prior to test.

3.6 COMMISSIONING SYSTEM

A. The Contractor shall furnish, install, and set all regulators based on capacity and pressure as shown on drawings. Provide a plugged tee for measuring downstream pressure from regulator. A U-tube water manometer shall be used to adjust the leaving pressure. Provide a record of the entering and leaving pressure for each regulator.

3.7 CLEANUP

A. Upon completion of the installation of all outside utilities, Contractor shall remove all surplus construction materials and debris resulting from the work.

END OF SECTION 22 6801

SECTION 23 0500 - COMMON WORK REQUIREMENTS FOR HVAC

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. See General Conditions and Supplemental General Conditions.

B. The requirements listed under General Conditions and Supplemental General Conditions and the General Requirements are applicable to this Section and all subsequent sections of this Division and form a part of the contract.

C. See Division 2, Site Work for additional requirements regarding Trenching, Backfilling for buried piping.

D. Refer to specification Section 01 8113 Part 1.5 for LEED product submittal requirements.

1.2 INDEX OF SPEC SECTIONS FOR THIS DIVISION

23 0500	Common Work Requirements for HVAC
23 0501	Demolition
23 0504	Pipe and Pipe Fittings
23 0505	Piping Specialties
23 0523	Valves
23 0549	HVAC and Electrical Installation Coordination
23 0550	Variable Frequency Drives
23 0593	Testing, Adjusting and Balancing of Mechanical Systems
23 0700	Mechanical Systems Insulation
23 0800	Mechanical Facility Startup/Commissioning for HVAC
23 0900	Facility Management System for DDC Controls
23 2113	Heating Hot Water System and Equipment
23 2123	Pumps
23 2313	Refrigerant Piping System and Equipment
23 3000	Air Tempering System and Equipment
23 3423	HVAC Power Ventilators
23 3713	Diffusers, Registers, and Grilles
23 3813	Kitchen Exhaust and Makeup Air Systems
23 5216	Condensing Boilers
23 7313	Modular Indoor Central Station Air Handling Units

1.3 DEFINITIONS

A. General: Terms will have meanings as defined in Webster's Eleventh New Collegiate Dictionary except as noted below.

B. Entities

1. Owner: Dziłth-Na-O-Dith-Hle Community School

2. Contractor: Jaynes Coorporation
3. Architect: FBT
4. Engineer: Bridgers & Paxton
5. Owner's Representative: The Owner will designate his representative after bid. The abbreviation “OR” may be used throughout these specifications to refer to the Owner’s Representative.
6. Owner's Agents: The Architect, Engineer, and others authorized to act on behalf of the Owner.

C. Actions

1. Supply: Procure and deliver to the site with all features as specified, required per code, and as required for proper installation. Include submittals, O&M manuals, operator instructions, and warranty.
2. Install: Set in place in accordance with manufacturer's instructions, contract documents, and applicable codes and standards. Coordinate the installation with other disciplines, start, and demonstrate proper operation.
3. Furnish: Supply and install.
4. Provide: Supply and install.
5. Accepted: By the Owner’s Representative except as noted.
6. Approved: By the Owner’s Representative except as noted.
7. Review: By the Engineer except as noted.

D. Locations

1. Buried: Surrounded by soil or other material, either beneath the building or exterior to the building.
2. Exterior: Exposed to rain or snow. Examples include rooftop locations, spaces around cooling towers, pipe racks, etc.
3. Interior: Not exterior or buried. Examples include not only spaces within the heated envelope of the building, but also unheated attics, covered loading docks in which spaces are protected from rain and snow, utility tunnels, sheds, etc.
4. Finished Spaces: Interior spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct chases, unheated attics, spaces above ceilings, crawlspaces, and tunnels.
5. Exposed: Exposed to view. Examples include finished spaces mechanical equipment rooms, rooftops, etc.
6. Concealed: Not Exposed.

E. Other Definitions:

1. 24/7: 24 Hr/day, 7 days per week, year-round.
2. AHJ: Authorities having jurisdiction. The authorities having jurisdiction over this project are established by statute, and include governmentally designated building departments, the fire marshal, fire departments, etc. No attempt is made to list all such entities here; a qualified Contractor is expected to know and coordinate with the various authorities having jurisdiction.
3. FMS: Facility Management System
4. Local: Based no further from the job site than the Engineer is. For example, where the specifications call for a local factory authorized service agent, then on a daily basis that agent must be based in an office or warehouse located no further from the project site

than the Engineer's office.

5. OAE: Or approved equal.

1.4 CODES AND PERMITS

A. Perform all work in accordance with the Building Construction and Safety Code NFPA 5000, Code, the 2015 Uniform Plumbing Code, and the 2015 Uniform Mechanical Code, as adopted and interpreted by Indian Affairs and the National Fire Protection Association (NFPA Regulations), current adopted edition. Provide all materials and labor necessary to comply with rules, regulations and ordinances. Where the drawings and/or specifications indicate materials or construction in excess of code requirements, the drawings and/or specifications shall govern. Contractor shall hold and save the Owner and his agents free and harmless from liability of any nature or kind arising from the Contractor's failure to comply with codes and ordinances.

B. Secure and pay for all permits necessary for performance of the work, including utility connections, extensions, meter pits and meter sets and tap fees for water, storm sewer, sanitary sewer and natural gas, unless otherwise specified herein.

C. Comply with the requirements of, and the recommendations of:

1. Applicable county and state mechanical, electrical, gas, plumbing, health and sanitary codes, laws and ordinances
2. National Electrical Manufacturer's Association
3. National Electrical Code
4. Underwriters Laboratories
5. American National Standards Institute
6. American Society for Testing Materials
7. Local utility companies
8. National Fire Protection Association
9. ASME Boiler and Pressure Vessel Codes
10. Occupational Safety and Health Administration
11. International Fire Code
12. Midwest Insulation Contractors' Association (MICA)
13. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)
14. American Society of Sanitary Engineering
15. American Gas Association

1.5 PRIOR APPROVAL

A. Refer to Division 1 for Prior Approval Requirements.

1.6 DOCUMENT MANAGEMENT

A. Contractor is encouraged to use a web-based document management system for RFIs and submittals. If used, Contractor shall provide and pay for licenses and training for the engineer's project personnel. The section below describes procedures for handling submittals if a web-based document management system is not used. If a web-based system is used, the procedures below shall be modified as appropriate.

1.7 SUBMITTALS

A. See Division 1 and individual specification sections within this division for additional submittal requirements.

B. Refer to specification Section 01 8113 Part 1.5 for LEED product submittal requirements.

C. Prior to purchasing materials, equipment and services, submit descriptive literature for review.

D. See Division 1 and individual specification sections within this division for additional submission requirements. The following describes general submittal procedures. More specific procedures will be established after award. Whenever electronic files are to be submitted, e-mail them through normal channels. But if files are too large to e-mail, then submit them in quantities as described below.

1. Submittal Schedule: Along with the first item submitted for review, include a schedule listing all items to be submitted and an approximate date for each submittal. Submit this schedule in both hard copy and electronic form (Microsoft Excel). Normal review time will be 10 working days or as indicated in Division 1. Schedule should identify any submittals for which expedited review is requested. Update this schedule and resubmit it monthly (by e-mail) for information.
2. Include the following information with each submittal:

    a. Cover sheet identifying the project name, contractor, architect, engineer, and items included. Indicate symbol numbers, spec section, etc.
    b. A blank space large enough to accept a review stamp.
    c. Performance under the specified conditions
    d. Cover sheet shall clearly identify and **HIGHLIGHT** any ways in which the submitted materials, equipment or services deviate from the Specifications.

3. Quantities:

    a. Brochures: Submit no more than seven copies plus a PDF.
    b. Drawings: Submit one reproducible, one print, plus a PDF.

4. Engineer will review one original submittal and one resubmittal for each item. If the Contractor fails to provide the required data or acceptable items with his second submittal, he will be charged for the Engineer's costs for the third and subsequent reviews.
5. Required Information: Submit information to allow the Engineer to easily determine whether the submitted components comply with the general design intent. Include relevant descriptions of materials, features, performance, quality and dimensions. Cross out all features, options and accessories which will not be provided. It is assumed that all specified, indicated and/or required features will be provided unless specifically noted otherwise.
6. Where specifications require a local factory authorized service agent, submit the name, address, and contact information for this agent. Include this information also in the O&M Manual.

E. Review of Submittals: Engineer will review submittals for general conformance with the design intent.

1. Review of a separate item as such will not indicate review of the assembly in which the item functions.
2. Review of submittals shall not relieve the Contractor of responsibility for any deviation from the requirements of the Contract Documents, nor for errors or omissions in the submittals; or for the accuracy of dimensions, the adequacy of connections, and the proper and acceptable fitting, execution, functioning and completion of the work.
3. Review will not relieve the Contractor of responsibility to comply with the contract requirements, or responsibility to ensure that equipment fits within the allotted space with required clearances for equipment operation, service and maintenance, including minimum clearances required by applicable codes, manufacturer's installation instructions and as necessary for proper clearance in front of all electrical panels as defined by the National Electric Code (NEC).
4. For commodity type items (plumbing fixtures, terminal units, registers, diffusers, etc), Engineer will review submittals for type only. Contractor to coordinate sizes and quantities.
5. Actions: Engineer will return submittals with one of the following actions:

NO EXCEPTIONS TAKEN	Contractor may proceed with the work as submitted
EXCEPTIONS AS NOTED	Contractor may proceed with the work and without resubmittal provided he complies with all exceptions noted in the submittal, and so states in a letter
REVISE AND RESUBMIT	Resubmit in accordance with the indicated comments
REJECTED	Resubmit in accordance with the contract documents
RETURNED WITHOUT ACTION	This submittal has not been reviewed, and therefore the Engineer is returning it with no direction to the Contractor.

F. Substitutions:

1. Unauthorized Substitutions: If substitute materials, equipment or systems are installed without prior review or if any work is installed in a manner which is not in conformance with the requirements of this specification and for which the Contractor has not received written authorization, remove such unauthorized work and install work in accordance with the contract documents at no change in contract amount.
2. Authorized Substitutions: Provide all accessories and features as required and coordinate substitutions with other disciplines. Bear any extra expenses resulting from the use of substitutions which affect adjoining or related work required in this division or other divisions of the work.
3. If the Contractor substitutes equipment for that indicated on the drawings, he shall prepare a 1/4 inch = 1foot installation drawing for each equipment room where a substitution is made, using dimensions of substituted equipment, and including piping, and electrical equipment requirements, to verify that equipment will properly fit within the space with adequate clearance for maintenance and replacement. Submit this drawing for review.

G. Schedule: Submit all submittals in a timely manner consistent with the requirements for completing the work covered by this contract within the prescribed contract time. Be aware that there is risk in ordering components, fabricating work, and/or installing work prior to review. If the Contractor proceeds prior to review, and then the review comments required modifications to work which has begun or has been completed, then Contractor must comply with the review comments at no change in contract amount or schedule.

H. Shop Drawings

1. Submit shop drawings for

    a. Mechanical equipment rooms and other spaces housing air handling equipment, heat transfer equipment, fluid handling equipment, machinery, etc.
    b. Complete supply, return, and exhaust ductwork systems, both exposed and concealed.
    c. Piping for HVAC, plumbing, and fire protection systems, both exposed and concealed.

2. Show the location and elevation of all equipment, ductwork and piping, as well as openings through slabs and walls. Include plans, elevations and sections as appropriate. Clearly show the manner in which the systems fit into the available space and relate to each other and to the building elements. Indicate required sleeves and openings in general construction elements. Indicate required clearances for operation, maintenance and replacement of operating devices and equipment. Drawings shall be of appropriate scale to facilitate coordination and understanding, but not smaller than 1/4 inch scale for floor plans and 1/4 inch scale for equipment rooms and chases.
3. Conflicts: The engineer has endeavored to work out conflicts in areas where the design is congested, but has not tried to show all required offsets to coordinate with the building construction and building systems, particularly in less congested areas. The intent is that the Contractor coordinate the design of the piping and ductwork distribution systems with the building construction and the various building systems, particularly in less congested areas. Provide experienced designers to perform such services and prepare shop drawings. Exercise good design practice in working out conflicts without compromising system operation or maintenance. Provide fittings, offsets, etc., as required. Contractor shall include this design effort and include the labor and materials for such fittings and offsets in his base bid. Except in extremely unusual circumstances, no additional costs will be allowed related to working out conflicts. Coordinate with other disciplines as required. Identify on the shop drawings those areas where redesign was necessary to resolve design conflicts.

    a. In the event that the Contractor desires direction in resolving a design conflict or desires prior approval of a recommended approach to resolving a conflict, submit an RFI which identifies the conflict and suggests a recommended solution.
    b. In resolving conflicts, gravity lines and larger distribution mains will generally have priority over pressurized lines and smaller lines as follows:

        Plumbing waste and vent lines
        Roof drains
        Steam and condensate piping
        Supply, return and exhaust ductwork

Fire sprinkler mains
Heating hot water and chilled water piping
Domestic hot and cold water
Fire sprinkler branch piping and sprinkler runouts
Pneumatic control piping
Miscellaneous special piping systems

4. Use of Engineer's CADD Database or BIM Model: The Engineer will provide the Contractor electronic files of the Engineer's CADD Database or BIM Model of the design documents if the Contractor completes and submits the License Agreement form included at the end of this spec section. These files show the general design intent and may be used as a starting point for the Contractor to begin his shop drawings and coordination effort, but the Contractor should not use them as a basis for ordering or fabrication. The normal submittal process still applies, regardless whether the Contractor elects to use the Engineer's CADD Database or BIM Model.

I. Submittals Required under this Specification Section:

1. Electrical Components: Motors, Motor Controllers, and Variable Speed Drives
2. Identification: Products used to identify equipment, ductwork, valves, piping, and control devices.
3. General Construction Components: Roof Curbs & Access doors.

1.8 DOCUMENTED COORDINATION EFFORT

A. After shop drawings are reviewed, incorporate any review comments and then participate in a formal and documented coordination effort with the contractors and subcontractors for other divisions of the work. Show all piping systems and equipment on the ductwork drawings, and send electronic CADD files to the General Contractor and the subcontractors for plumbing, fire protection, electrical, and other disciplines. The other subcontractors will then add their work to the CADD files.

B. Make full-size plots of the drawings. Participate in meetings with the GC and other subcontractors to review each area, identify conflicts, and resolve conflicts. Submit the resolutions to the Engineer for review. Maintain adequate space for operation, maintenance, and code-required clearances. Ensure that all subcontractors initial each plan to indicate that they have participated in the coordination effort.

1.9 MISCELLANEOUS PROVISIONS

A. Qualifications

1. All mechanics shall be skilled in their respective trade.
2. All welders shall be certified in accordance with the ASME Boiler Test Code, Section IX, latest issue.

B. Regulated Materials: Comply with all state, local and federal regulations regarding the storage, handling or disposal of oils, lubricants, cleaning agents, refrigerants, other liquids and gases, and hazardous materials.

C. Factory Identification: Provide all materials and equipment with labels sufficient to show compliance with these specifications and the performance requirements indicated on the drawings. All equipment shall carry a permanent label installed by the manufacturer stating that the equipment complies with ASHRAE/IESNA Std. 90.1.

D. Hazardous Conditions: Protruding metal (bolts, steel angles, etc.) potentially hazardous to maintenance and operation personnel, shall be cut back and/or protected to reduce the risk of injury.

E. Hazard Signs

1. Provide a sign reading, "Hazardous Area - Authorized Personnel Only" on the doors to all equipment rooms, fan plenums, and similar areas containing moving or rotating parts, or other potentially hazardous environments.
2. Provide a sign reading, "Confined Space - Entry by authorized personnel only by permit" for all confined spaces. Confined spaces shall be as designated by OSHA Standard 1910.146. This generally means a space that:

    a. Is large enough and so configured that an employee can bodily enter and perform assigned work; and
    b. Has limited or restricted means for entry or exit (for example, tanks, vessels, storage bins, hoppers, vaults, and pits are spaces that may have limited means of entry); and
    c. Is not designed for continuous employee occupancy.

3. Survey the final premises to determine where any potentially hazardous areas exist. If the Contractor feels that hazards exist which cannot be suitably provided for through the above typical methods, he shall forward in writing his concerns, and request for a decision concerning the referenced hazard, prior to the final inspection of the facilities.

1.10 GUARANTEE-WARRANTY

A. See Division 1 for additional information on warranties. Warranties shall run for one year from substantial completion unless indicated otherwise.

B. The following warranty shall be binding:

> "The Contractor warrants that this installation is free from mechanical defects. Contractor agrees to replace or repair any part of the installation which may fail within a period of one year after the date established below, provided that such failure is due to defects in materials or workmanship, or to failure to follow the specifications and drawings. This warranty shall begin on the date set forth in the Certificate of Substantial Completion, AIA Form G704, or other such date as documented in writing by the Owner's Representative."

C. The extent of guarantees or warranties by equipment and/or materials manufacturers will not diminish the requirements of the Contractor's warranty to the Owner.

PART 2 - PRODUCTS

2.1 PRODUCT GENERAL REQUIREMENTS

A. General: Products supplied under Division 23 shall comply with the following except as noted elsewhere.

B. Products shall be new; shall be the product of manufacturers regularly engaged in the production of plumbing, heating, ventilating, air conditioning, and control system equipment; and shall be the manufacturer's latest design. Specs and equipment schedules establish expectations regarding standard of quality and operating intent.

C. Hazardous or Environmentally Damaging Materials: Products shall not contain asbestos, mercury, PCBs, or other materials harmful to people or the environment.

D. Products shall be suitable for the conditions under which they are installed and operated. Prior to or during the submittal phase advise the Owner's representative and the Engineer in writing regarding any concerns about the suitability of the specified products for the intended application or service. Request clarification if any question exists regarding the design intent.

E. Performance Ratings: Unless otherwise noted, all scheduled equipment performance is based on an elevation of 5,600 feet above sea level. Adjust manufacturer's ratings accordingly.

F. Structural Soundness: Products shall have structural integrity appropriate to the component and its application. Bases shall be rigid and shall keep all components in proper alignment. Structural integrity shall be adequate for both rigging and final installation. Components shall not be loose, rattle, or vibrate unnecessarily in their final installed condition.

G. Corrosion Resistance: Equipment shall be of materials inherently corrosion resistant, or shall be finished with a corrosion-resistant finish suitable for the location in which the equipment is installed.

H. Touch-up: If the factory finish of any component is damaged prior to substantial completion, touch up to original condition per manufacturer's recommendations.

I. Equipment Access Doors or Panels: Provide access doors and panels within equipment to ensure good access to all components requiring inspection, service or maintenance. Provide appropriate hardware. Equipment installed outdoors shall be weather-tight.

J. Fans: Statically and dynamically balanced, shaft first critical speed shall be above operating speed at design conditions.

K. Bearings: Grease lubricated or permanently lubricated.

L. V-Belt Drives: All components sized for 150% of motor HP, multiple belts shall be matched, fixed sheaves for motors 20 Hp and larger, adjustable sheaves for lower HP motors, all safety components for OSHA compliance (e.g., belt guard or other safety provisions) motor mounted on adjustable base. Provide a replacement sheave for each fixed sheave after T&B is complete. Include belt data in O&M manual. Gates Rubber Co, OAE.

1. Belt Guards: Rigidly constructed and attached, removable, galvanized steel, expanded mesh. Design to provide ready access to bearings.

M. Couplings: Provide coupling guard.

N. Motors and VFDs: See requirements described elsewhere in this spec section.

O. Drive Lines (starter or VFD, motor, coupling and shaft or v-belt drive and pulleys, and driven equipment): Coordinate with all suppliers and ensure all components are compatible to work as a system.

P. Coils: ARI rated, copper tubes mechanically expanded into aluminum fins, galvanized steel casing, drainable, pressure tested to 150% of working pressure but not less than 300 psi.

Q. Cooling Coil Drain Pans: Provide for all cooling coils, galvanized or stainless steel, double pitched with piped outlet. For units with more than one coil stacked, provide intermediate drain pans piped to the main drain pan.

R. Gas Burners: Natural gas fired, performance based on gas at 1000 Btu/SCF HHV but suitable for use with gas at 900 – 1050 Btu/SCF and 7 – 11 inches water column, factory installed and pressure tested gas train, all necessary safety and operating controls.

S. Filter Frames: Galvanized steel, provide wherever filters are specified.

T. Provide submittals as required by Section 01 8113 Supplemental Table(s):
1. Submittal Requirements for LEED v4 Materials and Resources Credits.
2. Submittal Requirements for LEED v4 Environmental Quality Credits.

U. Roof Curbs and Support Rails for Roof-Mounted Equipment: Roof curbs should generally be supplied with the equipment which the curb supports, and shall comply with the requirements of the National Roofing Contractors' Association. Match curb to the requirements of the supported equipment. The roof pitch is indicated on the architectural drawings. If roof pitch exceeds the recommendations of the equipment manufacturer, provide a curb that will level the equipment. Factory fabricated, minimum 12-inch, structurally adequate for the load supported, not less than welded 18-gauge (16-gauge or heavier for sizes more than 50-inches) galvanized steel with minimum 1-inch fiberglass insulation, 2 x 2 wood nailer, and with cant and step if required to match specified roof. Provide damper tray for un-ducted fan applications. Ship small curbs fully assembled; large curbs may be knocked down for shipment.

V. Electrical & Controls: Except where specifically noted, electric service to each component listed on the equipment schedules will be through a single electrical feed at the voltage indicated on the equipment schedules. Include all components, cabling and conduits to distribute power to all components which are factory supplied and mounted. Provide transformer(s) if required to serve unit-mounted components requiring electric service at voltages different from the main electric service, including controls components. Provide secondary overcurrent protection. Provide terminal strips for field-installed control wiring. Provide unit-mounted, unit-specific wiring diagrams on durable paper, attached to inside of control panel door or otherwise affixed to the unit. All electrical components shall be UL Listed or Recognized. All factory-installed electrical work shall comply with the NEC unless the overall unit is listed by an organization acceptable to the AHJ, and listed to a standard

acceptable to the AHJ.

1. Where equipment includes an LCD or other, similar display for operator interface, display all information in English. Displays should be readily understandable and should not require the user to look up display codes in a reference manual.
2. Provide battery backup to retain all memory and programming, and to keep all clock-related functions powered through a 1-week power outage.
3. Controls interface with the FMS:

    a. Digital Inputs to FMS: 24V DC sourced from equipment.
    b. Digital Outputs from FMS: Equipment to have form C relays, max 250V DC, 2 A.
    c. Analog Inputs to FMS: 4-20 mA, 0-5V DC, or 0-10V DC sourced from equipment.
    d. Analog Outputs from FMS: 4-20 mA sourced from FMS.

2.2 ELECTRICAL COMPONENTS

A. General: Except as noted, all electrical products and equipment shall comply with the requirements of this section, whether field installed or factory installed. See "Product General Requirements" and "Installation General Requirements" in Parts 2 & 3 of this spec section for additional requirements.

B. Motors

1. General: Except as noted motors shall be horizontal, open drip-proof, 4-pole, 1750 RPM, rated per NEMA MG-1, with fabricated steel or cast iron casing, motor terminal box adequately sized for conductors one-size larger than specified, SS nameplate per NEMA MG-1-20.60, connection diagram attached to motor, compression lugs for power feeds and ground conductor, grease lubricated sealed ball bearings or roller bearings with standard grease fitting zerk and relief tapping, factory lubricated, dynamically balanced to no more than 50% of the NEMA allowable vibration limits. For motors powering V-belt drives, provide a cast iron or steel base with slide rail and adjustable belt tension device. Install motors and equipment on foundations and align as required. 40 deg C rise and total temperature rise of 65 deg C ambient.

    a. 3/4 hp and smaller: 115V, single phase, 60 Hz, split phase or permanent split capacitor (PSC), NEMA Type N or O, with built-in thermal overload protection.
        1) Multi-speed motors.
    b. 1 hp and greater: 3 phase, 60 Hz, squirrel cage induction type, NEMA design B, T-frame, with Class B or F insulation, lifting lugs, 150,000 hr L-10 bearings for direct-coupled applications, 50,000 hr L-10 bearings for belt-driven application with radial loads and pulley sizes per NEMA MG1-14.43. Service Factor: ODP motors shall be rated for 1.15 SF at 40^{o}C or 1.0 SF at 65^{o}C; TEFC motors shall be 1.0 SF.
        1) Two speed motors: Provide with two separate windings.
        2) Variable speed motors: Drive compatible per NEMA MG1-31, premium efficiency as specified below regardless of Hp, Class F insulation, minimum 5-year warranty.

2. Efficiency: Except as noted, motors shall be premium efficiency type, with nominal

efficiencies not less than the following as per the Consortium on Energy Efficiency (CEE), and minimum power factor of 0.85:

	Open Drip-Proof (ODP)			Totally Enclosed Fan-Cooled (TEFC)		
HP	1200 RPM	1800 RPM	3600 RPM	1200 RPM	1800 RPM	3600 RPM
1	82.5	85.5	80.0	82.5	85.5	78.5
1.5	86.5	86.5	85.5	87.5	86.5	85.5
2	87.5	86.5	86.5	88.5	86.5	86.5
3	89.5	89.5	86.5	89.5	89.5	88.5
5	89.5	89.5	89.5	89.5	89.5	89.5
7.5	91.7	91.0	89.5	91.7	91.7	91.0
10	91.7	91.7	90.2	91.7	91.7	91.7
15	92.4	93.0	91.0	92.4	92.4	91.7
20	92.4	93.0	92.4	92.4	93.0	92.4
25	93.0	93.6	93.0	93.0	93.6	93.0
30	93.6	94.1	93.0	93.6	93.6	93.0
40	94.1	94.1	93.6	94.1	94.1	93.6
50	94.1	94.5	93.6	94.1	94.5	94.1
60	95.0	95.0	94.1	94.5	95.0	94.1
75	95.0	95.0	94.5	95.0	95.4	94.5
100	95.0	95.4	94.5	95.4	95.4	95.0
125	95.4	95.4	95.0	95.4	95.4	95.4
150	95.8	95.8	95.4	95.8	95.8	95.4
200	95.4	95.8	95.4	95.8	96.2	95.8

3. Approved Manufacturers: General Electric Energy Saver, Baldor Super-E, Marathon Series E, Reliance Electric XE, Westinghouse TEE II, Eaton/Cutler Hammer, Toshiba, Louis Allis, or approved equal.
4. If the Contractor proposes to furnish motors varying in horsepower and/or characteristics from those specified, he shall first submit his request for the change and shall then coordinate the change with all other parties (e.g. electrical contractor) and pay any costs associated with the change.

C. Motor Controllers

1. Single Phase Manual Starters to 1 Hp and 120-277 V: Cutler Hammer MS with indicating light.
2. 3-Phase: Full voltage, non-reversing, electro-mechanical, combination circuit breaker and motor controller, UL Listed, NEMA rated, 460V, 65,000 AIC, minimum 50 VA 24V controls transformer with secondary overcurrent protection, suitable for operation at -4°F to +149°F and specified voltage -15% to + 10%, adjustable solid state overloads initially set at Class 10, HOA switch, run indicator, two auxiliary contacts for remote monitoring of status, and enclosure for surface mounting. Cutler Hammer OAE.

   a. Provide enclosure appropriate to the location:
      1) NEMA-1 for indoor dry locations.
      2) NEMA-3R for outdoors.
      3) NEMA-4 for wet applications.
      4) NEMA-12 for dusty locations.
      5) Explosion-proof – where required.

b. Motor controllers factory mounted and wired on AC units, boilers, etc, may be definite purpose, and need not have all the features specified here.

2.3 ELECTRICAL WIRING AND CONTROL EQUIPMENT

A. Provide wiring and conduit as scheduled in Section 23 0549.

B. Coordinate with all disciplines to ensure that all necessary components of control work are included and fully understood.

2.4 IDENTIFICATION

A. Scope: Identify all equipment, ductwork, valves, piping, and control devices shown on the Drawings, identified in the equipment schedules, and indicated in these Specifications. Provide submittals for products and procedures used for identification.

B. Equipment: For all mechanical equipment supplied or installed under Division 23, provide an equipment identification tag or stencil unit number onto the equipment. Stencils shall be minimum 3-inch height, dark contrasting color, of a material suitable for the application.

1. For rooftop HVAC equipment, provide a permanently affixed, weather-resistant label to identify the areas served.

C. Valves: Provide each valve with a stamped metal tag secured to the valve. Tag shall indicate the valve number, service and function. Provide two sets of prints of drawings showing floor plan for each floor with all valves accurately located and labeled. Drawings shall be neat and easily readable. Provide a typed valve chart, listing the valve number, size, location, function, normal operating position, for each valve. List valves by system, i.e., domestic cold water, hot water, chilled water, etc. Tags shall be stamped brass 1-1/2" diameter, and secured to valves by heavy copper figure eight hooks, braided stainless steel wire anchor, or other approved means.

D. Ductwork: Identify ductwork at or near the fan with stenciled signs on insulated ductwork or engraved laminated plastic signs secured by rustproof screws on un-insulated ductwork. Sign shall identify air conditioning system or fan unit and area served.

E. Piping

1. Provide color-coded pipe labels indicating the service of the pipe and the direction of flow. Piping labels shall comply with ANSI Standard A13.1 regarding color coding and size of lettering. The following standardized color code scheme shall be used:

a. Yellow - Hazardous Materials.
b. Green - Liquid Materials of Inherently Low Hazard.
c. Blue - Gaseous Materials of Inherently Low Hazard.
d. Red - Fire Protection Materials.

2. Labels shall be semi-rigid plastic identification markers. Labels shall "span-on" around pipe without the requirement for adhesive or bonding of piping sizes 3/4 inch through 5 inches. Labels for piping 6 inches and larger shall be furnished with spring attachment at each end of label. "SETMARK" Type SNA, 3/4 inch through 5 inch size and Type STR, 6 inches and larger, as manufactured by Seton Name Plate Corporation, Brady, or equivalent.
3. Labels shall be vinyl material with permanent adhesive for application to clear dry pipe and/or insulation jacketing. Pressure sensitive pipe tape matching the background color of the label shall be placed over each end of the label and completely around the pipe.
4. For retrofit projects the system names shall match existing.
5. Attach pipe markers to lower quarter of the pipe on overhead horizontal runs and on the centerline of vertical piping where view is not obstructed.
6. Provide the following labels, with ANSI/OSHA color and banding for all piping systems as shown on the Drawings and as listed below:

Service/Legend	Letter Color	Background Color	Tape Banding Color
Domestic Cold Water	White	Green	2" Green
Domestic Hot Water	Black	Yellow	2" Yellow
Domestic Hot Water Return	Black	Yellow	2" Yellow
Soft Cold Water	White	Green	2" Green
Soft Hot Water	Black	Yellow	2" Yellow
Industrial Cold Water	White	Green	2" Green
Fire Protection Water	White	Red	2" Red
Fire Auto Sprinkler	White	Red	2" Red
Fire Dry Standpipe	White	Red	2" Red
Fire Wet Standpipe	White	Red	2" Red
Fire Comb. Standpipe	White	Red	2" Red
Compressed Air	White	Blue	2" Blue
Roof Drain	White	Green	2" Green
Sanitary Sewer	White	Green	2" Green
Storm Sewer	White	Green	2" Green
Natural Gas	Black	Yellow	2" Black
Steam, PSIG	Black	Yellow	2" Black
Condensate Return, Gravity	Black	Yellow	2" Black
Condensate Return, Pumped	Black	Yellow	2" Black
Boiler Feed Water	Black	Yellow	2" Black
Chilled Water Supply	White	Green	2" Green
Chilled Water Return	White	Green	2" Green
Heating Water Supply	Black	Yellow	2" Yellow

Service/Legend	Letter Color	Background Color	Tape Banding Color
Heating Water Return	Black	Yellow	2" Yellow
Condensing Water Supply	White	Green	2" Green
Condensing Water Return	White	Green	2" Green

7. Locations: Label pipes at the following points on each piping system:

   a. Adjacent to each valve in piping system.
   b. At every point of entry and exit where piping passes through a wall.
   c. On each pipe riser and junction.
   d. At a maximum interval of 20 feet on pipe lines exposed and concealed above accessible ceilings.
   e. Adjacent to all special fittings (regulating valves, etc.) in piping systems.
   f. At every access door.

8. Underground Piping: Provide a continuous, preprinted, bright colored, plastic ribbon cable marker with each underground pipe regardless of whether encased. Locate directly over buried pipe, 6 inches to 8 inches below finished grade. Marker tape used in conjunction with buried plastic piping systems shall be special detector type.

F. Control System Devices: All automatic controls, control panels, zone valves, pressure electric, electric pressure switches, relays and starters shall be clearly tagged and identified. Wording shall be identical to that on the control diagram in the Contract Drawings.

2.5 GENERAL CONSTRUCTION COMPONENTS

A. Roof Curbs and Equipment Support Rails

1. General: Factory fabricated, minimum 12-inch high, galvanized steel, configured to account for roof pitch where pitch exceeds 1/4-inch/ft or where required by manufacturer of supported equipment. Coordinate with roofer and provide cant and step if needed to match roof construction. Actual curb heights to be coordinated by contractor with roofing insulation height to maintain code-required height above final roofing elevation.
2. Roof Curbs: 1.5-inch fiberglass insulation with nominal 2" x 2" wood nailer. Provide damper tray where a damper is indicated. Thycurb TC, Greenheck, RPS, OAE.
3. Equipment Support Rails: Nominal 2" x 4" wood nailer. Thycurb TEMS, Greenheck, RPS, OAE.

B. Access Doors (ADs)

1. Steel frame and door, surface mounted, factory primed, 150^{o} opening, flush, screw-driver operated cam lock, minimum 24” x 24” except as approved, but larger where required for proper access. Where ADs are installed in general construction with a pattern, match AD dimensions to this pattern. Milcor, Krueger, OAE.

   a. Sheet Rock Wall or Ceiling: With drywall bead on frame, Milcor Style DW.
   b. Plaster Wall or Ceiling: Milcor Style K.

c. Masonry Walls: Milcor Style M.
d. 1-hr and 2-hr rated walls: UL Listed for 1.5-hr Class B Fire Rating, self-closing and self-latching. Milcor Style UFR.
e. Suspended Ceilings: Milcor Style AT.
f. Fire Rated Suspended Ceilings: Milcor Style ATR.

C. Painting: Finish painting of mechanical systems and equipment will be under Spec Section 09 9100, “Painting," unless equipment is specified to be provided with factory-applied finish coats.

2.6 MISCELLANEOUS PROVISIONS

A. Flow Diagrams: Provide half-size prints of each system flow diagram, including air handling, steam, chilled water, heating water, domestic water, domestic HW, etc. Mount framed under plexiglass, and locate either on the associated AHU or on a nearby wall. Incorporate any as-built revisions.

PART 3 - EXECUTION

3.1 INSTALLATION GENERAL REQUIREMENTS

A. Cooperation with Other Trades: Refer to other parts of these Specifications covering the work of other trades which must be carried on in conjunction with the mechanical work so that the construction operations can proceed without harm to the Owner from interference, delay, or absence of coordination. Be responsible for the size and location of all openings, foundations, etc.

B. Trenching and Backfilling: Provide all excavation, trenching and backfilling required for the installation of the work of this division.

C. Manufacturer's Instructions: Install all products in accordance with manufacturers’ recommendations and the requirements of any applicable listings. If manufacturers’ recommendations and/or requirements of applicable listings conflict with plans and specifications, report such conflicts to the Owner's Representative.

D. Field Measurements: Verify all dimensions and conditions governing the work. Examine adjoining work on which the work of this Division is dependent, and report any deficiencies.

E. Do not compromise the building structural, fire resistant construction or vapor barrier system.

F. Supports for Equipment and Systems: Foundations and structural supports for equipment will generally be provided by others. The contractor for this division shall provide supplementary supports as required to support equipment, distribution systems, and other components installed under this division. Prior to installing mechanical work, examine foundations and supports to ensure they are adequate to properly support the equipment. Provide all necessary foundations, structures, supports, inserts, sleeves, etc, for installation of mechanical and plumbing equipment, ductwork and piping, etc. Coordinate installation of such devices with all disciplines. Verify that the devices and supports are adequate as intended and do not overload the building structure.

G. Concealed or Buried Work: For work which is underground or which will be concealed by building construction, provide digital photographs to document the installation throughout the construction project, but not less than weekly. Include plans indicating where the photographs were taken. Notify the OR of when the work will be complete and provide OR a minimum five-day period to inspect the work after completion but prior to when it is backfilled or concealed by building construction.

H. Access Doors: Provide as required for access to valves, dampers, controls, or other items for which access is required for either operation or servicing. The type of access door shall be as required by the room finish schedule.

I. Provide submittals as required by Section 01 8113 Supplemental Table
   1. Submittal Requirements for LEED v4 Environmental Quality Credits.

J. Alignment of Flexible Couplings: Flexible couplings between motors and driven equipment shall be aligned by a qualified service technician after the equipment is installed and ready for operation. Align equipment per manufacturer's recommendations under operating conditions and temperature. Provide written certification that each device has been so aligned.

K. Lubrication: Provide all oil for the operation of all equipment until acceptance. Be responsible for all damage to bearings while the equipment is being operated by Contractor up to the date of acceptance of the equipment. Protect all bearings and shafts during installation and thoroughly grease shafts to prevent corrosion. Bearings for items of mechanical equipment shall be marked at each bearing location as to whether the bearing is a sealed type or relubricable type unit.

L. Tests: All tests shall be conducted in the presence of the designated and authorized Owner's Representative. Notify the Owner's one week in advance of all tests. Requirements for testing are specified under the sections covering the various systems. Provide all necessary equipment, materials, and labor to perform the required tests.

M. Protection of Material and Equipment:

   1. Protect all work, materials and equipment furnished and installed under Division 23, whether incorporated in the building or not.
   2. All items of mechanical equipment shall be stored in a protected weatherproof enclosure prior to installation within the building, or shall be otherwise protected from the weather in a suitable manner as approved.
   3. Protect all work and be responsible for all damage done to property, equipment and materials. Coordinate material storage with the Owner's Representative.
   4. Pipe and duct openings shall be closed with caps or plugs, or covered to prevent lodgment of dirt or trash during the course of installation. Plumbing fixtures shall not be used by the construction forces. At the completion of the work clean and polish fixtures, equipment and materials prior to turning them over to the Owner.

N. Systems Commissioning: A commissioning Agent will participate in the construction phase of the project.

3.2 DRAWINGS

A. The drawings show the general arrangement of the piping, ductwork, equipment, etc. Follow them as closely as actual building construction and work of other trades will permit. Where discrepancies occur between Plans and Specifications, the more stringent shall govern. All Contract Documents shall be considered as part of the work. Because of the small scale of the drawings, it is not possible to indicate all offsets, fittings and accessories, which may be required, and no attempt has been made to do so. Rather, the drawings convey the general design intent. Investigate the structural and finish conditions affecting the work and arrange the work accordingly, providing fittings, valves, and accessories as required to meet such conditions. Show any such changes on the Record Drawings.

B. Should any doubt or question arise in respect to the true meaning of the drawings or specifications, submit an RFI.

C. Install equipment, piping, ductwork, and electrical systems with proper clearance for operation, service, and maintenance, including minimum clearances required by applicable codes, manufacturer's installation instructions, etc. Include proper clearance in front of and above electrical equipment as defined by the National Electric Code (NEC). Piping and ductwork systems shall not be routed through or above electrical equipment rooms, telecommunications rooms, elevator machine rooms, or electrical equipment spaces within mechanical equipment rooms.

D. Arrange all concealed mechanical systems carefully to fit within the available space without interference with adjacent structural and electrical systems. Make all necessary provisions for penetrations of piping and ductwork, including sleeves and blockouts in structural systems. The exact location of all exposed mechanical systems, including grilles, registers, and diffusers; access doors; sprinkler heads; piping and ductwork exposed within finished areas; and other equipment and devices as applicable, shall be coordinated with the Architect, who shall have final authority for the acceptance of the work as it relates to the aesthetic design for the facility.

3.3 INTERRUPTING SERVICES

A. Coordinate the installation of all work within the building in order to minimize interference with the operation of existing building mechanical, plumbing, fire protection, and utility systems during construction. Connections to existing systems requiring the interruption of service within the building shall be carefully coordinated with the Owner to minimize system downtimes. Requests for the interruption of existing services shall be submitted in writing a minimum of two weeks before the scheduled date. Absolutely no interruption of the existing services will be permitted without written review and authorization.

3.4 CONCRETE BASES AND HOUSEKEEPING PADS

A. Concrete bases and housekeeping pads shall be installed under all pieces of mechanical equipment unless specifically deleted by the Specifications or Drawings.

B. Be responsible for the accurate dimensions of all pads and bases and furnish and install all vibration isolators, anchor bolts, etc.

C. Provide concrete housekeeping pad foundations for all floor mounted equipment installed under this section unless otherwise shown on the Drawings. All concrete bases and housekeeping pads shall conform to the requirements specified under Division 3, Concrete, portions of these

Specifications. Pad foundations shall be 4 inches high minimum, unless otherwise indicated on the Drawings. Chamfer edges shall be 1 inch. Faces shall be free of voids and rubbed smooth with carborundum block after stripping forms. Tops shall be level. Provide dowel rods in floor for lateral stability and anchorage.

D. Equipment anchor bolts shall be set in a galvanized pipe or sheet metal sleeves 1 inch larger than bolt diameter. Anchor bolts shall be high strength steel J-shape. Anchor bolt design shall be arranged and paid for by the Contractor.

E. Machinery bases, bed plates, sole plates, or vibration isolation units shall be carefully aligned, shimmed, leveled, and then grouted in place with commercial non-shrink grout. When a flexible coupling is employed as a part of the drive train, the coupling shall be aligned before the machinery base is grouted.

3.5 PRESSURE RELIEF DEVICES

A. Refrigerant pressure relief devices and fusible plugs shall be installed with piping to a safe location in accordance with ANSI/ASHRAE Standard 15. Discharge shall be to atmosphere at a location not less than 15 feet above the adjoining ground level and not less than 20 feet from any window, ventilation opening, or exit from any building. Discharge line sizing shall conform to ANSI/ASHRAE Standard 15-1994.

B. Each discharge pipe shall be equipped with a drip leg capable of holding 1 gallon of liquid. The drip leg shall include a manual drain valve.

3.6 INSTALLATION CHECK

A. An experienced, competent, and authorized representative of the equipment listed below shall visit the site of the work and inspect, check, adjust if necessary, and approve the installation for the equipment listed below. The equipment supplier's representative shall revisit the job site as often as necessary until all trouble is corrected and the equipment installation and operation is approved and accepted.

B. Each equipment supplier's representative shall furnish a written report certifying that the equipment (1) has been properly installed and lubricated; (2) is in accurate alignment; (3) is free from any undue stress imposed by connecting piping or anchor bolts; and, (4) has been operated under full load conditions and that it has operated satisfactorily.

C. Equipment requiring installation check includes the following:

Boilers
Domestic Hot Water Heaters
Water Treatment Systems (Boilers)
Air Handling Units
Facility Management System (See Specification Section 23 0900)
Aircooled Condensers

3.7 OPERATION PRIOR TO ACCEPTANCE

A. Operation of equipment and systems for the benefit of the Owner prior to substantial completion will be allowed provided that a written agreement between the Owner and the Contractor has established warranty and other responsibilities to the satisfaction of both parties.

B. Operation of equipment and systems for the benefit of the Contractor, except for the purposes of testing and balancing, will not be permitted without a written agreement between the Owner and the Contractor establishing warranty and other responsibilities.

3.8 OPERATION AND MAINTENANCE (O&M) INSTRUCTIONS

A. At completion of the project provide two complete bound sets of the following documents, along with two CDs containing searchable PDFs of these documents. Organize bound information in a logical fashion with a table of contents and tabs for the different sections. Organize PDFs in a logical fashion with bookmarks to assist the operating personnel in retrieving desired data. Provide minimum two 1-hour sessions to instruct Owner's facility personnel in how to find information in the bound O&Ms and the PDFs. Take attendance and submit the attendance list to the Owner's Representative. Include the following:

1. Approved Submittals.
2. Test reports.
3. O&M manuals and instructions covering all equipment supplied under this Division, with all non-applicable information crossed out. Clearly identify all required routine maintenance. Include parts lists.
4. A master Lubrication Chart listing each piece of equipment, the recommended oil or grease, and the recommended frequency of lubrication.
5. The names and addresses of at least one service agency capable of providing required maintenance for each item of equipment supplied.
6. Complete temperature control diagrams including control descriptions, system sequence of operation, operating instructions, control system maintenance and calibration information, wiring diagrams, and all control setpoints. See Section 23 0900 for additional requirements.

B. See Division 1 for additional requirements concerning manuals, manual distribution, and maintenance materials.

C. Submit O&M manuals for review and distribution to the Owner not less than two weeks prior to the date scheduled for O&M instructions as specified.

D. Demonstrate proper system operation to the owner's operating staff. Provide the services of the contractor and subcontractors (e.g., mechanical, T&B, temperature control, etc), as required to properly demonstrate system operation.

E. Provide the necessary skilled labor and helpers to operate the mechanical systems and equipment for a period of 5 days of eight hours each. During this period, instruct the owner’s facility staff fully in the operations, adjustment and maintenance of all equipment provided. Provide at least two weeks advanced notice, with a written schedule of each training session, the subject of the session, the Contractors' Representatives who plan to attend the session, and the time for each session. Take attendance and submit attendance sheets to the Owner's

Representative.

F. Film the instruction and training sessions submit two copies of video to owner.

3.9 RECORD DRAWINGS

A. See Division 1, for additional requirements associated with Project Record Drawings.

B. Maintain a full-size set of marked-up prints showing the installed location and arrangement of all work under this division, and in particular where changes were made during construction. Keep record drawings accurate and up-to-date throughout the construction period. Owner's Agents may request to review record drawings during construction and in conjunction with review and approval of monthly pay requests. Include copies of all addenda, RFIs, bulletins, and change orders neatly taped or attached to record drawing set. At the completion of the project send the Engineer full-size plans clearly showing all changes from the original design marked up in red so as to facilitate the Engineer incorporating these changes into the Engineer's CADD files. Forward record drawings to the Owner's Representative prior to submitting a request for substantial completion.

3.10 SITE VISITS AND OBSERVATION OF CONSTRUCTION

A. The Engineer may make periodic visits to the project site at various stages of construction in order to observe the progress and quality of various aspects of the work so as to determine if such work is proceeding in general accordance with the Contract Documents. This observation will not release the Contractor from his responsibility to supervise, direct, and control all construction work and activities. The Engineer has no authority over, or responsibility for means, methods, techniques, sequences, or procedures of construction or for safety precautions and programs, or for failure of the Contractor to comply with applicable laws, regulations, or codes.

B. Prior to substantial completion, request that the Engineer provide a final observation visit. Complete the attached "Final Observation Checklist," and include it with this request. For any items that are not applicable, mark them "N/A."

3.11 PROJECT CLOSEOUT

A. Submit written certification that all work complies with the specifications and applicable codes. Submit certifications and acceptance certificates including proof of delivery of record drawings, O&M manuals, spare parts required, and equipment warranties.

END OF SECTION 23 0500

Project:_____ Date Submitted:_____

General Contractor:_____ Date of Final Mechanical System:_____

Mechanical Contractor:_____ Observation Requested:_____

CONTRACTOR'S MECHANICAL & PLUMBING CHECK LIST
(ALL APPLICABLE ITEMS MUST BE COMPLETED PRIOR TO FINAL OBSERVATION)

In advance of requesting a final mechanical observation for installed mechanical systems, please check all items that have been completed. For all items not applicable to this project mark N/A.

PLUMBING/PIPING

_____1. All plumbing fixtures are set, sealed and cleaned.

_____2. All domestic and HVAC pipe systems are insulated.

_____3. All pipe systems are identified with specified labels and directional arrows.

_____4. Floor sinks and drain grates are cleaned and debris removed.

_____5. Valve tags are installed.

_____6. Special equipment (water softeners, water heaters, piping systems, etc.,) have been checked and put into service.

_____7. Medical gas systems have been checked and certified.

_____8. Special piping systems have been cleaned and pressure tested.

_____ Fuel Handling
_____ Compressed Air
_____ Natural Gas
_____ Other

_____ Process Piping
_____ Nitrogen
_____ Vacuum
_____ Argon
_____ Medical Gas
_____ Other

_____9. Limestone chips have been installed in acid dilution sumps.

_____10. Plumbing/piping connections have been completed to Owner-furnished equipment and equipment furnished by other Contractors/Subcontractors.

_____11. Exterior wall hydrants have been cleaned.

_____12. Concrete collars have been installed at clean-out to grade, valve box, or other specified plumbing items.

_____13. Drains and relief lines from plumbing and HVAC equipment have been installed and secured in a proper manner.

_____14. All plumbing equipment and areas of equipment have been cleaned and debris removed.

_____15. All plumbing equipment required by the Specifications has been identified and/or numbered.

_____16. Domestic water systems sterilization has been completed.

_____17. Refrigerant piping/system has been charged and tested.

_____18. Strainers/suction diffusers have been cleaned.

_____19. Backflow preventers have been tested.

_____20. Air has been vented from all coils and systems.

_____21. Water treatment systems have been charged and tested.

_____ Chilled Water
_____ Hot Water
_____ Condenser Water
_____ Steam/Condensate

_____22. Ethylene glycol system has been charged with correct mixture and tested.

_____23. Water systems have been cleaned (X) and pressure tested (P)

_____ Chilled Water
_____ Hot Water
_____ Steam
_____ Condensate
_____ Fire Protection
_____ Sanitary Sewer and Vent
_____ Roof and Overflow Drains
_____ Condenser Water
_____ Non-potable Water
_____ Domestic Hot Water
_____ Domestic Cold Water
_____ Acid Waste and Vent
_____ Heat Recovery Piping
_____ Other (list)

_____24. PRVs have been adjusted (water, steam, gases).

FIRE PROTECTION

_____1. Fire protection piping is completed.

_____2. Fire protection system has been certified by the Fire Marshal's office.

_____3. All electrical interlocks between the fire sprinkler components and the fire panel have been checked for operation.

_____4. Spare sprinkler head, wrench and cabinet are installed.

HVAC - EQUIPMENT AND DUCTWORK

_____1. All ductwork has been sealed and insulated.

_____2. Return air paths and transfer openings have been verified.

_____3. Air handlers have been cleaned inside and out and construction filters removed and replaced with final filters.

_____4. All air handling equipment has been started and operated for the specified time.

_____5. All equipment isolators have been adjusted for specified deflection.

_____6. All VAV boxes, fan coils, or fan powered boxes are completed and operational.

_____7. All pump shafts and couplings have been aligned.

_____8. Ductwork, coils, housing, diffusers, registers and grilles have been cleaned.

_____9. Boilers have been fired and certified by the supplier.

_____10. Cooling towers have been started and inspected by the supplier.

_____11. Chillers have been charged, started and certified for operation by the supplier.

_____12. Fire dampers are accessible and fully operational.

_____13. All HVAC equipment has been lubricated.

_____14. HVAC equipment has been labeled in accordance with the Specifications.

_____15. Duct pressure testing is complete and accepted.

_____16. "HAZARDOUS AREA" signs installed where applicable.

_____17. Belt guards installed where applicable.

_____18. Variable frequency drives have been tested by the manufacturer's representative and certified to be in compliance with all of the specified requirements.

_____19. Testing and balancing has been completed, and deficiencies noted have been corrected.

_____20. Special systems have been started and tested, such as: Humidification, laboratory hoods, kitchen hoods, and Owner-furnished items.

TEMPERATURE CONTROLS

_____1. Temperature control panels and devices have been labeled in accordance with the Specifications.

_____2. All control dampers close completely and edge and blade seals form tight seal.

_____3. All control valves have been piped as required by the Drawings.

_____4. Controls systems are completed and all control points are operating and recording properly.

_____5. All temperature control tubing and wiring is installed and secured in accordance with the Specifications and the electrical code.

_____6. Smoke removal fans and/or smoke detectors have been tested for operation and shutdown.

_____7. Freezestats have been tested ensuring fan shutdown and full damper closure.

_____8. Operator training for temperature controls has taken place.

_____9. Refrigerant sensors and equipment room shutdown have been tested.

GENERAL ITEMS

The following specified items have been submitted:

_____1. Record Drawings (to be submitted prior to final payment to the Contractor).

_____2. Operation and maintenance manuals.

_____3. Manufacturer's representative installation check and certification submitted (see list of equipment, Section 23 0500).

_____4. Testing and balancing reports.

_____5. Test kits furnished to Owner.

_____ Flow Measuring Devices
_____ Flow Balance Valves
_____ Flow Control Devices

_____6. Temperature control schematics and sequence of operation.

_____7. Wall-mounted lubrication, valve, and temperature control charts have been installed.

DIVISION 23 SUBSTITUTION REQUEST FORM (SRF)

TO: BRIDGERS & PAXTON CONSULTING ENGINEERS
PROJECT: _____

We hereby submit for your consideration the following product instead of the specified item for the above project:

Section: _____ Page: _____ Paragraph/Line: _____ Specified Item: _____

Proposed Substitution: _____

Attach complete product description, drawings, photographs, performance and test data, and other information necessary for evaluation. Identify specific Model Numbers, finishes, options, etc.

1. Will changes be required to building design in order to properly install proposed substitutions? YES ☐ NO ☐
   If YES, explain: _____
2. Will the undersigned pay for changes to the building design, including engineering and drawing costs, caused by requested substitutions? YES ☐ NO ☐
3. List differences between proposed substitutions and specified item.

Specified Item	Proposed Substitution
_____	_____
_____	_____

4. Does substitution affect Drawing dimensions? YES ☐ NO ☐
5. What affect does substitution have on other trades? _____
6. Does the manufacturer's warranty for proposed substitution differ from that specified? YES ☐ NO ☐
   If YES, explain: _____
7. Will substitution affect progress schedule? YES ☐ NO ☐
   If YES, explain: _____
8. Will maintenance and service parts be locally available for substitution? YES ☐ NO ☐
   If YES, explain: _____
9. Does proposed product contain asbestos in any form? YES ☐ NO ☐

SUBMITTED BY: Firm: _____ Date: _____
Address: _____
Signature: _____ Telephone: _____

For Engineer's Use Only

Accepted _____	Not Accepted _____	Received Too Late _____
By: _____		Date: _____
Remarks: _____		

LICENSE AGREEMENT FOR CADD DATABASE OR BIM MODEL

PROJECT: _____

LICENSE GRANT: Contractor is granted use of the CADD Database or BIM Model (Database/Model) for the indicated project for the specific purpose of preparing submittal documents for this Project. No other use of the Database/Model is granted. Title to the Database/Model is not transferred to the Contractor. The Database/Model may be of value to the Contractor in preparing submittals, but use of the model does not relieve the contractor of the requirement to verify measurements in the field.

COPYING RESTRICTIONS: Contractor may copy the Database/Model in whole or in part, but only for backup and archival purposes or for use by the Contractor's Subcontractors. Contractor agrees to ensure that any entities that receive the Database/Model from Contractor, either in whole or in part, comply with the terms and conditions of this agreement. Contractor shall safeguard the Database/Model from falling into the hands of parties other than Subcontractors with a legitimate need for it.

WARRANTY: Bridgers & Paxton (B&P) offers this Database/Model without warranty and specifically without express or implied warranty of fitness. If Contractor chooses to use the Database/Model, then he does so at his own risk and without any liability or risk to B&P.

INDEMNITY: Contractor shall to the fullest extent permitted by law, defend, indemnify and hold harmless the Owner, Architect, B&P, their employees and agents from all claims, damages, losses, and attorney fees arising out of or resulting from the use of the Database/Model.

ACKNOWLEDGMENT: Contractor acknowledges that (s)he has read this Agreement, understands it, and agrees to be bound by its terms and conditions.

CONTRACTOR'S REPRESENTATIVE

Signature: _____ Company Name: _____

Name: _____ Address 1: _____

Title: _____ Address 2: _____

Date: _____

SECTION 23 0501 - DEMOLITION

PART 1 - GENERAL

1.1 REQUIREMENTS

A. Conform with applicable provisions of the General Conditions, Supplemental General Conditions and the General Requirements.

1.2 RELATED SECTIONS

A. See Section 23 0500, for Common Work Requirements for HVAC.

B. See Division 1, for Cutting and Patching.

1.3 SCOPE OF WORK

A. The terms "demolish" and "remove" shall mean disconnect, cart away, and dispose of off site. Components to be demolished or removed include all materials, equipment, building construction, and other components as indicated. Components to be demolished shall become the property of the contractor, and contractor may dispose of them by either landfilling or by selling salvageable parts and recyclable materials to legitimate third parties.

B. Except as specifically noted, asbestos abatement will be by others, and is not included in this contract. Advise Owner sufficiently in advance of demolition work so that Owner may arrange to have asbestos removed without delaying demolition or construction work.

C. The Owner retains the first right of refusal on all components to be removed. When requested, remove components carefully and deposit components in locations as directed by the Owner.

PART 2 - PRODUCTS

Not Applicable.

PART 3 - EXECUTION

3.1 GENERAL

A. Within four weeks after notice to proceed, and a minimum of two weeks prior to any demolition activities, submit a project schedule indicating all demolition work. Schedule all work to minimize interruptions in utility services to the facility. Interruptions generally will be allowed only outside normal operating hours. Sequence all work in accordance with the drawings and the Project Manual.

B. Take care not to damage equipment, materials, components, and building construction which is to remain in service. Provide blind flanges, caps, etc, so as to prevent accidental discharge of water, etc.

C. Do not interfere with the Owner's access to buildings and equipment. If any activities cause interference which is objectionable to the Owner, contractor shall modify his means and methods, or reschedule those activities outside occupied hours at no additional cost to the Owner.

D. Where existing systems must remain in service during the construction project, make whatever provisions are necessary to accomplish this. This includes providing blind flanges and caps, temporary insulation, duct caps, etc, to allow for proper system operation.

3.2 EQUIPMENT

A. General: Disconnect and remove piping, ductwork, controls, power, and equipment supports. Wherever possible, remove equipment as a whole. Do not cut up equipment in place unless approved in advance by the Owner.

B. Chillers: Drain water in evaporator and condenser to sanitary sewer system. Remove refrigerant and either recycle or dispose of as a hazardous material. Remove oil and dispose of as a hazardous material. Comply with all applicable regulations, including the Clean Air Act and RCRA. Submit documentation showing final owner and location of refrigerant and oil.

C. Boilers: Water in boiler, condensate system, and boiler feed system may be drained to the sanitary sewer system. Remove boilers, steam piping, blowdown systems, condensate piping, condensate pumps, boiler feed pumps, safety relief piping, breeching, stacks, and all associated piping and accessories. Repair concrete floor. Remove chemicals and chemical feed equipment. Chemicals shall be either reused by chemical supplier, or properly disposed of in accordance with all applicable regulations including RCRA. Submit documentation showing final owner, location, and means of disposal for chemicals.

D. Cooling Tower: Drain water to sanitary sewer system. Disassemble tower as required, cart away, and dispose of all components. Wood members shall be disposed of as hazardous materials. Comply with all applicable regulations, including RCRA. Submit paperwork documenting the final owner, location, and means of disposal for all wood members. Demolish and cart away the concrete basin for the cooling towers and condenser water pumps. Backfill with approved fill material to grades which will ensure proper drainage. Compact to 95% Standard Proctor Density. Restore surfaces as indicated.

3.3 PIPING

A. Disconnect piping as indicated, and remove all piping not required in the final, upgraded condition of the systems. This includes removal back to the headers and mains which must remain in service. The existing valving may not hold tight. Arrange in advance for shutdowns as required. Provide caps, blind flanges, etc. as indicated on drawings, as required to facilitate construction activities, and as required to facilitate owner's use of the system.

B. Remove all components in piping system, including valves, fittings, flanges, strainers, anchors, guides, hangers, supports, supplementary steel, attachments to structure, instrumentation, insulation, etc.

C. Patch all openings in walls, floors, roofs, partitions, gratings, etc, which remain after piping is removed.

D. Provide vents and drains in the piping which will remain in service, where necessary to facilitate refilling, venting, and future system operation.

3.4 DUCTWORK

A. Disconnect ductwork as indicated, and remove all ductwork not required in the final, upgraded condition of the systems. This includes removal back to the mains which will remain in service. Arrange in advance for shutdowns as required. Provide caps as indicated on drawings, as required to facilitate construction activities, and as required to facilitate the Owner's temporary and final use of the systems.

B. Remove all components in ductwork system including fittings, dampers, grilles, registers, diffusers, louvers, hangers, supports, supplementary steel, attachments to structure, instrumentation, insulation, acoustic lining, etc.

C. Patch all openings in walls, floors, roofs, partitions, gratings, etc, which remain after ductwork is removed.

3.5 CONTROLS

A. Remove all controls associated with equipment, piping and ductwork which are to be removed. Controls shall include instrumentation, control panels, wiring, conduits, tubing, supports, and attachments to structure. Where wiring is run in conduit in concealed locations, remove the wiring, cap both ends of conduit, and label conduit as "ABANDONED" at both ends.

3.6 ELECTRIC POWER

A. Remove all electric power associated with equipment, controls and accessories which are to be removed. Electric power shall include starters, disconnects, wiring and conduit from MCC's and distribution panels to local starters and disconnects, wiring and conduit from local starters and disconnects to equipment, supports, attachments to structure, and concrete housekeeping pads. Label all associated breakers as "SPARE." Where MCC's serve equipment to be removed and no new equipment is to be served from the same starter, leave the starter in place and label it as "Spare Size X Starter."

B. Where wiring runs in conduit within concealed locations, remove the conductors, cap both ends of conduit, and label conduit as "ABANDONED" at both ends. Where wiring runs below grade, remove conductors, cap conduit at both ends, and abandon in place. Where wiring runs below concrete floor slabs, chip out concrete around conduit, remove conduit to bottom of slab level, and patch floor to match adjacent surfaces.

3.7 EQUIPMENT SUPPORTS

A. Housekeeping Pads: Remove housekeeping pads for equipment to be removed. Remove all tripping hazards and resurface floor to match surrounding floor.

B. Equipment Foundations: Remove foundations, remove all tripping hazards, backfill as required, compact to 95% Standard Proctor Density, and pour floor slab to match existing.

C. Support Steel: Remove all support steel including attachments to building or to grade.

3.8 MEANS OF ACCESS

A. Remove all service platforms, catwalks, ladders, etc. which are required solely for the equipment, valves, and instrumentation which are being removed as part of this work.

3.9 TEMPORARY REMOVALS

A. Carefully remove and store the following components for reinstallation under this contract. Report any operating deficiencies prior to removal. After reinstallation, place components back in service and demonstrate proper operation.

END OF SECTION 23 0501

SECTION 23 0504 - PIPE AND PIPE FITTINGS

PART 1 - GENERAL

1.1 REQUIREMENTS

A. Conform with applicable provisions of the General Conditions, Supplementary Conditions and General Requirements.

B. Lead Ban: All piping, solder and flux used in the installation of piping systems furnished and installed under Division 23, shall be lead free. The term lead free is defined as pipe which does not contain more than 8.0% lead and solder and flux which does not contain more than 0.2% lead.

1.2 RELATED SECTIONS

A. See Section 23 0500, for Common Work Requirements for HVAC.

1.3 SUBMITTAL DATA

A. Contractor shall furnish complete submittal data for all piping materials, including manufacturer's specifications, certifications, class, type and schedule. Submittal data shall additionally be furnished for pipe hangers and supports, pipe sleeves including sealing and fire safing materials and installation.

PART 2 - PRODUCTS

2.1 PIPE AND PIPE FITTINGS

A. Piping system materials shall be furnished as specified under the Sections describing the various piping systems. Pipe fittings shall be compatible with the piping systems in which they are installed. All HVAC gravity condensate drainage piping system shall be wrought copper conforming to ANSI B16.22.

B. Pipe fittings for steel piping systems shall be weld, screwed. Butt weld fittings shall be manufactured by Weld-Bend, Laddish, or equivalent, standard or extra strong as specified in the applicable Sections of this Specification, conforming to ANSI Standard B16.9. All 90^0 weld elbows shall be long radius unless otherwise specified. Wherever tee connections are required in the piping system, manufacturer's straight or reducing tees shall be utilized. The use of fittings formed from welded pipe or pipe sections will not be permitted. Forged steel "Weld-O-Lets," "Branch-O-lets," and "Thred-O-Lets," as manufactured by Bonney Forge or equivalent, may be utilized for welded branch and tap connections up to one-half the size of the main. Forged steel half-couplings conforming to ANSI B16.11 may be used for drain, vent and gauge connections. Flanges shall be forged steel weld neck or slip-on, raised face, Class 150 or 300 as specified in the applicable Sections of this Specification with full face or ring type non-asbestos gasket material suitable for the application.

C. Socket weld fittings shall be Schedule 40, 2000 pound or Schedule 80, 3000 pound construction, as specified in the applicable Sections of this Specification, conforming to ANSI B16.11, as manufactured by Grinnell or equivalent.

D. Screwed fittings shall be Class 150 standard or Class 300 extra heavy, black or galvanized, malleable iron or cast iron, as specified in the applicable Sections of this Specification, as manufactured by Grinnell or equivalent. Screwed malleable iron fittings shall conform to ANSI B16.3 and cast iron screwed fittings shall conform to ANSI B16.4. Bushing reduction of a single pipe size or use of close nipples will be permitted.

E. Pipe fittings for copper piping system shall be wrought copper conforming to ANSI B16.22. Cast brass fittings conforming to ANSI B16.23, may be utilized for sanitary drainage, waste and vent systems, HVAC gravity condensate drainage system, and other non-pressure applications.

F. Bronze flanges, Class 125 and Class 150, shall conform to ANSI B16.24.

G. Cast iron fittings for cast iron sanitary soil, waste, and venting piping systems shall be as specified in Division 22.

H. Ductile iron fittings for ductile iron water service piping systems shall be as specified in Division 22.

2.2 FLOOR, WALL AND CEILING PLATES

A. Where uncovered, exposed pipes pass through finished floors, finished walls, or finished ceilings, they shall be fitted with chromium plated spun brass escutcheon plates. Plates shall be large enough to completely close the hole around the pipe, and shall be not less than 1-1/2" or more than 2-1/2" larger than the diameter of the pipes. All plates shall be securely held in place.

2.3 UNIONS

A. Piping 2-1/2" and larger shall be provided with bolted flange union connections. Weld flanges and bolting shall conform to ANSI B16.5. Bronze flanges shall conform to ANSI B16.24. Flange class shall be as specified in the applicable Sections of the Specifications.

B. Malleable iron grooved joint unions with brass to iron seats, Class 125, 250, or 300, as required by the application and compatibility requirements with the piping system fitting classification, conforming to MSS SP-77 and ANSI B16.39, shall be provided in piping systems 2" and smaller. Copper unions conforming to ANSI B16.22 shall be provided in copper piping systems. Union connections shall be installed at all coils, control valves, equipment connections, and at other locations shown on the drawings, and required for proper system operation and maintenance.

2.4 DIELECTRIC FITTINGS

A. Dielectric insulating fittings shall be provided to connect dissimilar metals, such as copper tubing to ferrous metal pipe. Connections 2" and smaller shall be threaded dielectric union conforming to ANSI B16.39. Connections 2-1/2" and larger shall be flange union with dielectric gasket and bolt sleeves, conforming to ANSI B16.42. Insulating fittings will not be required between bronze valves and copper piping, unless otherwise specified.

2.5 PIPE HANGERS AND SUPPORTS

A. All piping shall be rigidly supported from the building structure by means of hanger assemblies properly selected and sized for the application in accordance with the manufacturer's recommendations and specifications. Pipe hangers shall be Grinnell, B-Line, or equivalent.

B. No attempt has been made to show all required piping supports in all locations, either on the drawings or in the details. The absence of pipe supports and details on any drawing shall not relieve the Contractor of the responsibility for furnishing and installing proper hangers and supports throughout.

C. Piping hangers shall be spaced on the scheduled maximum spacing and shall have hangers not more than one foot from each elbow and other changes in direction or elevation. Provide additional hangers and supports at valves, strainers, in-line pumps adjacent to flexible connections, and other required heavy components. Piping system shall be installed in an approved manner and shall not overload the building structural frame. Contractor shall provide additional hangers and miscellaneous steel supports as may be required to distribute the piping system load over multiple structural members where required or directed. Maximum allowable spacing for steel and copper piping, other than fire protection piping, shall be as scheduled in Table No. 1.

TABLE NO. 1

MAXIMUM SUPPORT SPACING FOR STEEL

AND COPPER PIPING SYSTEMS

Steel Piping	- Maximum Spacing
1/2"	- 5'-0"
3/4" and 1"	- 6'-0"
1-1/4" through 2"	- 8'-0"
2-1/2" through 6"	- 10'-0"
8" through 12"	- 12'-0"
Copper Piping	**- Maximum Spacing**
1/2"	- 5'-0
3/4" through 2"	- 6'-0"
2-1/2" through 4"	- 8'-0"
5" and larger	- 10'-0"

D. Round rods supporting the pipe hangers shall be of the minimum dimensions as scheduled in Table No. 2. Hanger rods shall be hot-rolled steel, ASTM A-36 or A575, galvanized, all-thread. Provide for controlling level and slope by turnbuckles or other approved means of adjustment and incorporate locknuts.

TABLE NO. 2

HANGER ROD SIZE FOR PIPE HANGER SUPPORTS

1/2" to 2" pipe	- 3/8" rod
2-1/2" to 3" pipe	- 1/2" rod
4" to 5" pipe	- 5/8" rod
6" pipe	- 3/4" rod
8" to 12" pipe	- 7/8" rod
14" and 16" pipe	- 1" rod
18" and 20" pipe	- 1-1/4" rod
24" and 30" pipe	- 1-1/2" rod

E. Cast iron soil, waste and vent piping shall be provided with steel clevis type hangers. Grinnell Fig. 590 at each pipe joint and at each fitting.

F. Hanger spacing for plastic piping system support shall be as scheduled below in Table No. 3 for PVC and CPVC piping, based on pipe full of liquid with specific gravity of 1.0. See Table No. 5 for specific gravity correction factors. Piping may be continuously supported with a "V" or "U" shaped support made of metal or heat resistant approved plastic material. Hanger supports shall be in accordance with piping system manufacturer's recommendations.

TABLE NO. 3A

MAXIMUM SUPPORT SPACING FOR PVC AND CPVC PIPING SYSTEMS

SCHEDULE 40 PVC - MAXIMUM SPACING

OPERATING TEMPERATURE (DEGREE F)

	PVC AND CPVC			CPVC				
Size	60 & less	80	100	120	140	160	180	200
1/2" and 3/4"	5.5	5	4.5	4	3	3	3	2.5
1" and 1-1/4"	6	5.5	5.5	4.5	3.5	4	3.5	3
1-1/2" and 2"	6	6	5.5	4.5	3.5	4.5	4	3.5
2-1/2" and 3"	7.5	7	6.5	5.5	4.5	5.5	5	4
4"	8	7.5	7	6	4.5	6	5.5	4.5
5" and 6"	8.5	8	7.5	6.5	5	7	6	5
8"	9.5	9	8.5	7	5.5	7.5	6.5	5.5
10"	10	9	8.5	7	5.5	--	--	--
12"	10.5	10	9	8	6	--	--	--

TABLE NO. 3B

MAXIMUM SUPPORT SPACING FOR PVC AND CPVC PIPING SYSTEMS

SCHEDULE 80 PVC - MAXIMUM SPACING

OPERATING TEMPERATURE (DEGREE F)

	PVC AND CPVC			CPVC				
Size	60 & less	80	100	120	140	160	180	200
1/2"	6	6	5.5	4.5	3.5	3	2.5	2
3/4"	5.5	5	3.5	3	2.5	2		
1" and 1-1/4"	7	6.5	6	5	4	3.5	2	2.5

1-1/2" and 2"	7.5	7	6.5	5.5	4	4	3.5	3
2-1/2" and 3"	8.5	8	7.5	6.5	5	4.5	4	3
4"	9.5	9	8.5	7	5.5	5.5	5	3.5
5" and 6"	10	9	8.5	7	5.5	6	5.5	4
8"	11.5	11	10	8.5	6.5	6.5	6	4.5
10"	12.5	12	11	9.5	7	--	--	--
12"	13.5	13	12	10	8	--	--	--

TABLE NO. 5

SPECIFIC GRAVITY CORRECTION FACTOR FOR PLASTIC PIPING SYSTEMS

Specific Gravity:	1.0	1.1	1.2	1.4	1.6	2.0	2.5
Correction Factor:	1.0	0.98	0.96	0.93	0.90	0.85	0.80

G. Fire protection system shall be supported in strict accordance with the requirements contained in the applicable NFPA pamphlets and as specified in Division 21, Fire Suppression Systems.

H. Hangers, clamps and other support materials in contact with copper piping shall be copper or copper plated to prevent electrolysis. Hangers for copper piping shall be copper plated adjustable ring type Grinnell Fig. CT-269, adjustable swivel ring, Grinnell Fig. CT69, Fig. CT-65 or adjustable clevis type or equivalent. Provide minimum 10 mil plastic wrap around copper pipe at any ferrous point of attachment including trapeze hangers, clamps, and other supports.

I. Hangers for steel shall be steel clevis type hangers, Grinnell Fig. 260 or equivalent.

J. Where piping is installed side by side, the Contractor may support the piping utilizing trapeze type hanger assemblies. Horizontal trapeze member shall be galvanized steel channel, not less than 1-1/2" x 1-1/2" x 12" gauge, or Unistrut. Contractor shall provide heavier steel members as required for the load to be supported and the distance span. Trapeze hangers shall not be utilized for fire and sprinkler piping and plumbing drain waste and vent piping. Hanger rods shall be as specified above, properly sized for the load supported but not less than 5/8" diameter. Uninsulated copper piping shall be isolated from the steel trapeze. Individual pipe shall be guided on the horizontal member at every other hanger point with 1/4" U-bolt fabricated from steel rod. Provide full circle galvanized sheetmetal insulation shield for insulated piping at trapeze hangers with U-bolt guide and galvanized sheetmetal insulation half-shield at other trapeze hangers. Insulation shield shall be 18 gauge minimum, Grinnell Fig. 167 or equivalent.

K. Where shown on the drawings and as required for the proper control of the system expansion and contraction piping, provide rolled type supports. Roller hangers shall be Grinnell Fig. 181 or equivalent and roll support for trapeze hangers and pipe racks shall be Grinnell Fig. 271 or equivalent complete with base plate.

L. Vertical piping shall be supported at each floor level by means of riser clamps, Grinnell Fig. 261 and Fig. G-121 copper clad for copper piping systems, or equivalent. Proper allowance for the expansion and contraction of the vertical risers shall be provided. Contractor shall submit shop drawings indicating proposed method for support and control of expansion and contraction of vertical piping.

M. The use of pipe hooks, chains, or perforated iron for pipe hanger supports will not be permitted.

N. All insulated piping systems specified in Section 22 0700, Plumbing Insulation and Section 23 0700, HVAC Insulation, shall be provided with individual hangers sized to encircle the insulation. See applicable sections for insulation thickness requirements. The specified piping systems where supported by means of trapeze hangers shall not rest directly on the trapeze horizontal members. The insulation at hangers and trapeze hangers shall be protected by means of insulation shield, Grinnell Fig. 167, or equivalent. Grinnell Fig. 160 or equivalent, curved steel pipe saddle, shall be provided at roll hangers. Contractor shall provide section of high density calcium silicate insulation or thermal hanger shields as manufactured by Pipe Shields, Inc., or equivalent, at all insulation piping system hanger and support points for piping 1-1/2" or larger.

O. Attachment of piping hangers to the building structure shall be provided in a manner approved by the Architect. The Contractor shall provide concrete inserts in the building construction at the time the concrete is poured and hangers shall be attached to these inserts. Self-drilling expansion anchors, Federal Specification FF-S-325, may be used in concrete construction not less than 4" thick. Applied load shall not exceed manufacturer's approved ratings. Power driven fasteners may be used in existing concrete or masonry not less than 4" thick where approved by the Architect. Attachment to steel construction shall be by means of beam clamps. Attachment to wood construction shall be by means of wood screws or lag bolts.

2.6 PIPE SLEEVES

A. Pipe sleeves shall be furnished and set by the Contractor and he shall be responsible for their proper and permanent location. Piping will not be permitted to pass through footings, beams or ribs except with written consent of the Architect. Pipe sleeves shall be installed and properly secured in place at all points where pipes pass through gypboard stud walls and concrete, and masonry construction and at all fire and smoke rated walls and partitions. Pipe sleeves, except sleeves in footings and beams shall be equal to Pipe Shields Incorporated Model WFB for walls, DFB for decks, or QDFB for corrugated decks, or equivalent. Each sleeve shall be adjustable, with annular spacing packed with UL approved mineral fiber fire safing material. Where insulated piping is installed, calcium silicate inserts to match the insulation thickness and extending 1" past the sleeve on both ends, shall be provided. Pipe sleeves in concrete and masonry construction, footings and beams shall be Schedule 40 black steel pipe. Pipe sleeves in gypboard construction shall be galvanized steel metal. Sleeves shall be not less than 1" or more than 2" larger in diameter than the pipe to be installed. Pipe sleeves in floors shall extend 2" above finished floor in chases and equipment room areas unless otherwise approved by the Architect. Openings between piping and sleeves shall be made watertight with plastic cement installed to a minimum depth of 2". Where pipes pass through exterior walls, the annular space between the wall and the pipe shall be sealed by sealing elements made of synthetic rubber, pressure plates, and cadmium plated bolts as manufactured by Link-Seal, or equivalent.

B. Uninsulated piping passing through fire walls, smoke wall, sound control walls and air plenum separations shall be sealed airtight to the adjacent construction by means of UL approved fireproof caulking materials.

C. Insulated piping passing through fire walls and smoke walls shall be provided with a section of UL approved fire safing insulation to match the required insulation thickness or Pipe Shields, Inc. pipe shield sleeves as specified above at the required wall penetrations. The space between the piping sleeve penetration and the adjacent wall Construction shall be sealed airtight with UL approved fireproof caulking material. Penetrations of gypboard sound walls and air plenum separators shall be caulked airtight with an approved caulking compound.

PART 3 - EXECUTION

3.1 PIPING INSTALLATION

A. Provide and erect, according to the best practices of the trade, all piping shown on drawings and required for the complete installation of these systems. The piping shown on the drawings shall be considered as diagrammatic for clearness in indicating the general run and connections, and may or may not in all parts be shown in its true position. The piping may have to be offset, lowered or raised as required or as directed at the site. This does not relieve the Contractor from responsibility for the proper erection of systems or piping in every respect suitable for the work intended as described in the specifications. In the erection of all piping, it shall be properly supported and proper provisions shall be made for expansion, contraction and anchoring of piping. All piping shall be cut accurately for fabrication to measurements established at the construction site. Pipe shall be worked into place without springing and/or forcing, properly clearing all windows, doors, and other openings and equipment. Cutting or other weakening of the building structure to facilitate installation will not be permitted. All pipes shall have burrs and/or cutting slag removed by reaming or other cleaning methods. All changes in direction shall be made with fittings. All open ends of pipes and equipment shall be properly capped or plugged to keep dirt and other foreign materials out of the system. Plugs of rags, wool, cotton waste or similar materials may not be used in plugging. All piping shall be arranged so as not to interfere with removal and maintenance of equipment or filters or devices; and so as not to block access to manholes, access openings, etc. Flanges or unions as applicable for the type of piping specified shall be provided in the piping at connections to all items of equipment including refrigeration machines. All piping shall be so installed to ensure noiseless circulation. All valves and specialties shall be so placed to permit easy operation and access, and all valves shall be regulated, packed and adjusted at the completion of the work before final acceptance. All piping shall be erected to ensure proper draining.

3.2 JOINTS

A. Caulked Joints: Caulked joints in hub-and-spigot piping and vent piping shall be packed firmly with white oakum, "Sealite No. 110," or hemp and caulked with pure molten lead not less than 1" deep. Resilient molded gasket joints or "Ty-Seal" may be used in lieu of lead and oakum for sanitary soil, waste and vent piping. No-hub pipe and fittings will be accepted with the exception that no-hub pipe and fittings shall not be allowed for buried installation.

B. Screwed Joints: Shall have American Taper pipe threads. Ream pipe ends and remove burrs after threading. Make up joints using Teflon tape or other approved compound applied to the male threads only.

C. Solder Joints: Copper tubing shall be cut square and burrs removed. Both inside of fittings and outside of tubing shall be well cleaned before sweating. Care shall be taken to prevent annealing of fittings and hard drawn tubing when making connections. Joints for sweated fittings shall be made with a non-corrosive paste flux and solid 95-5 Tin-antimony wire solder, unless otherwise specified. Cored solder will not be permitted. 50/50 lead solder shall not be permitted for any applications.

D. Welded Joints: On black steel piping 2-1/2" and above in size, the joints may be welded. Welding shall be done using either gas or electric welding equipment. Certified welders shall be used. Welders shall be certified in accordance with Section IX of ASME Boiler and Pressure Vessel Code, latest edition. All pipe surfaces shall be thoroughly cleaned before welding. Each joint shall be beveled before being welded. Piping shall be securely aligned and spaced, and the width of circumferential welds shall form a gradual increase in thickness from the outside surface to the center of the weld. All fittings used in the welded piping systems shall be standard ASA fittings, and shall be of standard pipe thickness. The Contractor shall provide a fireproof mat or blanket to protect the structure and adequate fire protection at all locations where welding is done. The use of fittings formed from welded pipe sections will not be permitted.

E. Flanged Joints: Flanged joints shall conform to the American Standard for cast iron flanged pipe fittings, Class 125, 150 or 300 as specified in the applicable Sections of these specifications. Gaskets shall be full face or ring type, non-asbestos, suitable for the service on which used.

3.3 PUMP AND EQUIPMENT CONNECTIONS

A. All piping connecting to pumps and other equipment whether connected utilizing flexible connectors or with solid pipe connectors, shall be installed without strain at the pipe connection of the equipment. The Contractor shall be required, if so directed, to disconnect piping to demonstrate that piping has been so connected.

3.4 EXPANSION AND CONTRACTION

A. The Contractor shall make all necessary provisions for expansion and contraction of piping with offsets or loops and anchors as required to prevent undue strain. Contractor shall provide shop drawings for proposed method and arrangement for control of expansion and contraction of piping. See Section 230505 for expansion joints, expansion compensators, pipe guides and pipe anchors.

3.5 PROTECTIVE COATINGS

A. All underground steel pipe shall be wrapped with "Scotchwrap" No. 50 tape or equivalent, to give not less than two complete layers on the entire underground piping system, or piping shall have X-Tru-Coat factory applied plastic protective covering.

3.6 FLUSHING, DRAINING AND CLEANING PIPE SYSTEMS

A. The Contractor shall flush out all water systems with water before placing them in operation. Other systems shall be cleaned by blowing them out with compressed air or nitrogen. After systems are in operation and during the test period, all strainer screens shall be removed and thoroughly cleaned.

B. See applicable HVAC piping system specification sections for chemical cleaning of piping systems.

3.7 TESTING

A. Before any insulation is installed or before piping is covered or enclosed, all piping systems shall be tested and proven tight at not less than 150% of the maximum service pressure which the piping systems will be required to handle. Piping system tests shall be as specified in the applicable sections of this Specification. All tests shall be witnessed and approved by the Architect.

B. All labor, material, and equipment required for testing shall be furnished by the Contractor. The Contractor shall be responsible for all repairs and retesting as required. All instruments and other equipment whose safe pressure range is below that of the test pressure shall be removed from the line or blanked off before applying the tests. To perform tests, all lines shall be flushed and cleaned.

C. All safety measures required by codes or ordinances or reasonably applicable to the situation shall be provided by the Contractor in conjunction with the testing of the piping systems.

D. Equipment or piping to be pressure tested shall not be insulated, covered, or concealed prior to that test. Underground piping may be partially backfilled prior to pressure test when required for application of the test except that joints shall remain exposed until after the test. Tie rods, clamps etc., shall be in place and fastened.

E. Tests shall not be used to establish pressure ratings.

F. Protect all piping and equipment against over pressure, collapse from vacuum, and hydraulic shock during the filling, testing and draining procedures. Seats of iron valves shall not be subjected to a pressure in excess of the maximum cold working pressure of the valve. Pressure tests against other closed valves shall not exceed twice the normal rating.

G. Apply test pressure only after the system and test medium are at approximately the same temperature, preferably not less than 60^0F. Note that some applicable codes may require testing above a specified minimum temperature.

H. Remove from the system all pumps, turbines, traps, expansion joints, instruments, control valves, safety valves, rupture discs, orifice plates, etc., which might be damaged by the test. Also remove all items such as orifice plates which might trap air in a system to be hydrostatically tested. Disconnect all instruments and air lines where copper tubing starts.

I. Systems may be separated into sub-systems for testing if such action will expedite or simplify the testing.

J. During hydrostatic testing of lines, provide temporary supports to prevent overstressing supports or hangers. When tests are completed, remove all temporary supports, locks, stops, etc., and adjust supports for their cold load and alignment.

END OF SECTION 23 0504

SECTION 23 0505 - PIPING SPECIALTIES

PART 1 - GENERAL

1.1 REQUIREMENTS

A. Contractor shall furnish and install all piping specialties necessary for satisfactory operation of the systems. Conform with applicable provisions of the General Conditions, Supplementary Conditions and General Requirements.

1.2 RELATED SECTIONS

A. Section 23 0500 for Common Work Requirements for HVAC.

B. Section 23 0504 for Pipe and Pipe Fittings.

C. Section 23 0523 for Valves.

D. Section 23 0700 for HVAC Insulation.

E. Section 23 0549 for HVAC & Electrical Installation Coordination.

1.3 SUBMITTAL DATA

A. Contractor shall furnish complete submittal data for all piping specialties including manufacturer's specifications, performance characteristics, ratings, installation instructions, certifications and approvals of listing agencies, wiring diagrams, and selection analysis.

PART 2 - PRODUCTS

2.1 STRAINERS

A. Strainers suitable for the application shall be furnished and installed on the high pressure side of pressure reducing valves, pressure regulating valves, suction side of pumps, inlet of indicating and control instruments and equipment subject to sediment damage, and as shown on the drawings. Strainers shall be "Y"-type unless basket strainers are indicated. Tee-type strainers will not be accepted. Strainer element shall be removable without disconnecting piping. Screens shall be Type 304 stainless steel with 1/8 inch perforations for water service, and 1/16 inch perforations for air and gas services. Every strainer shall be provided with a blow-off connection not less than 1/2" NPT and provided with a ball valve the full size of the strainer outlet tapping. Strainers located outside of mechanical equipment rooms and above ceilings shall be provided with hose connection and cap on the outlet of the blowoff valve. Strainers shall be Spirax Sarco, Armstrong, Febco, Grinnell, Hoffman, Keckley, Metraflex, Mueller, Yarway, or equivalent.

B. Strainers 2" and under for copper piping systems shall be threaded connection, bronze body, 250 PSIG maximum working pressure, suitable for steam, oil, gas and liquid service, Sarco BT or equivalent.

C. Strainers 2" and under for steel piping systems shall be threaded connection, bronze body, as specified above or cast iron body as specified herein, except all strainers in galvanized steel domestic water systems shall be bronze body. Cast iron strainers shall be threaded connection, 250 PSIG maximum working pressure, suitable for steam, oil, gas and liquid service, Sarco IT or equivalent.

D. Strainers 2-1/2 inches or larger shall be standard flanged connection ANSI-125, cast iron body, suitable for steam, oil , gas, and liquid service, 125 maximum working pressure at 353^{o} F maximum temperature, Sarco CI-125.

E. Basket strainers 2" and larger shall be standard flanged ANSI-125, cast iron body bolted cover, Type 304 stainless steel screen, suitable for steam or liquid service, 125 maximum working pressure at 353^{o}F maximum temperature, Sarco 528-B-125.

2.2 SUCTION DIFFUSERS

A. Suction diffusers shall be furnished and installed at the suction of pumps where indicated on the drawings. Suction diffuser outlet shall be not less than pump suction size and suction diffuser system inlet shall be a minimum of one size larger than suction diffuser outlet size. Suction diffuser shall provide for a smooth flow of water into the pump inlet, and shall be complete with strainer, adjustable support leg, and start-up strainer. Start-up strainer shall be removed at the final testing and balancing phase.

2.3 PRESSURE GAUGES

A. Pressure gauges for water, non-corrosive liquids, and gases shall be Weiss Series UG-1, Style B, Marshalltown, Ashcroft, Trerice, Weksler, or equivalent. Gauges shall be 4-1/2 inches diameter, unless otherwise indicated, aluminum case with no back flange, black enamel finish, aluminum threaded ring, aluminum dial with white background and black lines and numerals, bronze bourdon tube with brass socket and 1/4 inch NPT bottom connection. Accuracy shall be 1/2 of 1% of full scale range, minimum.

B. Pressure range shall be indicated on the drawings or if not indicated shall be selected so that the normal operating pressure is approximately 50% of the scale range. Provide compound and vacuum ranges when required by the application.

C. Provide brass pressure snubber for all gauges with properly selected filter disc for the application. Provide a brass ball valve for each gauge. Where a single gauge is shown with multiple pressure sensing points, such as pump suction, discharge and strainer pressure drop applications, provide a gauge valve for each pressure sensing point.

D. Gauges shall be field calibrated as required to provide accurate readings.

E. Gauges shall be installed in such a manner as to be easily readable from ground level. This shall include piping to an adjacent location and mounting gauges on wall or frames where required.

2.4 THERMOMETER AND THERMOMETER WELLS

A. Thermometers shall be Weiss, Moeller, Trerice, Duro, or equivalent, 9" case, straight form, back angle, or vari-angle arrangement as required by the installation requirements. Cases shall be V-shaped design, high pressure die cast aluminum, baked enamel finish, with heavy glass protected front firmly secured with spring action. Tube and capillary shall be mercury filled-magnifying lens "red reading" with accuracy of 1% of scale range, minimum. Stem shall be 3-1/2" for piping sizes through 6", and 6" for piping sizes 8" and larger. Provide stainless steel separable sockets sized for stem lengths required for the applications. Extension neck separable sockets shall be provided for installation in conjunction with insulated piping systems.

B. Thermometer scale ranges shall be as indicated on the drawings or if not indicated shall be selected as required for the services. Typical ranges shall be as follows:

Heating water (low temperature 120^{o}F, maximum)	0 - 160 degrees F
Heating water (above 120^{0}F)	30 - 240 degrees F
Domestic cold water	0 - 120 degrees F
Domestic hot water	30 - 180 degrees F

C. Thermometers shall be field calibrated as required to provide accurate readings.

D. Thermometers shall be installed in such a manner as to be easily readable from ground level. Provide vari-angle thermometers as necessary to meet this requirement.

2.5 MANUAL AIR VENTS

A. Provide manual air vents at locations indicated on the drawings, at the high point of all liquid piping system and as otherwise required for proper air elimination and liquid circulation.

B. Manual air vents shall be 1/2" brass ball valves as specified in Section 230523. Provide brass hose connection and plug on valve outlet.

2.6 AUTOMATIC AIR VENT

A. Provide automatic air vents for all separators, at the high point of all hydronic systems and at locations indicated on the drawings. Automatic air vents shall be 3/4" size, minimum. Provide manual shut-off ball valve between automatic air vent and piping system. Automatic air vents shall be float type, 150 PSIG maximum working pressure, 3/4" NPT system connection, Amtrol Model No. 720, Taco, Armstrong, Watson-McDaniel, Hofmann, or equivalent.

2.7 MANUAL DRAIN VALVES

A. Provide manual drain valves at locations indicated on the drawings, at the low points of all liquid piping systems, and as otherwise required for proper draining of systems. Manual drain valves shall be sized as shown on the drawings but not less than 3/4" size, brass ball valve, as specified in Section 230523. Pipe discharge from drain valves to floor drain, floor sink, or as otherwise directed for indirect discharge into sanitary sewer system. For drain valves located above ceiling or in location outside mechanical equipment areas provide brass hose connection and cap for valve discharge.

2.8 TEMPERATURE AND PRESSURE TEST PLUGS

A. Where shown on the drawings, and on the inlet and outlet of each coil, heat exchanger, heating and cooling water generating equipment, heat rejection equipment and heat recovery equipment and 3-way control valve, furnish and install temperature and pressure test plugs with Nordel valve cores and 1/2" NPT brass body with gasketed cap. Test plugs shall be Peterson Equipment #110, or equivalent. The combination pressure temperature test wells shall be a minimum of 1/2" standard pipe thread.

2.9 FLOW BALANCE VALVE

A. Furnish and install calibrated balance valve equivalent to Bell and Gossett "circuit-setter," Griswold, Taco, Armstrong, or equivalent at locations indicated on the drawings. Balance valves shall be brass or cast iron body, NPT or sweat connections through 3" size and flanged connections above 4" size, 125 PSIG working pressure minimum. Balance valve shall be equipped with two brass readout valves with integral EPT insert and check valve designed to minimize system fluid loss during balancing and monitoring process. Each valve shall be provided with a calibrated nameplate permitting accurate system balance. Flow balance valves shall be not less than full line size with maximum pressure drop of 10 feet.

2.10 WATER FLOW MEASURING DEVICES

A. Furnish and install cast iron wafer type flow meter equivalent to Bell & Gossett "OP-Series, "Griswold, Taco, Armstrong, or equivalent at locations indicated in the drawings. Flow meters shall be equipped with two brass readout valves with integral EPT insert and check valve designed to minimize system fluid loss during monitoring process. Flow meter shall be furnished with a calibrated nameplate specifying the flow range through a range of differential pressures. Water flow measuring devices shall be not less than full line size with maximum pressure drop of 10 feet.

2.11 AUTOMATIC FLOW CONTROL VALVES

A. Furnish and install constant flow control valves Griswold or equivalent at locations indicated on the drawings. Automatic flow control valves shall be factory calibrated to maintain constant flow within 5% over system pressure fluctuations of at least ten (10) times the minimum required for control. Flow control valves shall be cast iron body with stainless steel cartridges, two pressure readout ports with quick disconnect valves, metal identification tag attached to valve marked with rated flow GPM. Valves through 2-1/2" size shall be threaded connection, valves over 3" shall be wafer type

for mounting between flanges furnished and installed by the Contractor. Automatic flow control valves shall be 150 PSIG minimum working pressure.

2.12 TRIPLE DUTY VALVE

A. At the Contractor's option, triple duty valve as manufactured by Bell & Gossett or equivalent may be utilized at pump discharge in lieu of non-slam check valve and balance/shut-off valve. Triple duty valve shall incorporate non-slam check valve with spring-loaded weighted disc and a calibrated adjustment feature permitting regulation of pump discharge flow and shut-off. Valves shall be designed to permit re-packing under full line pressure. Unit shall be installed on discharge side of pump in a horizontal or vertical position with the stem up. Unit shall be cast iron body construction suitable for maximum working pressure of 175 PSIG and maximum operating temperature of 300^{o}F, bronze disc and seat, stainless steel stem and spring.

2.13 FLEXIBLE CONNECTORS

A. Furnish and install flexible connectors at locations indicated on the drawings and at all piping connections associated with equipment mounted on or hung from vibration isolators. Flexible connectors shall be constructed of multiple ply nylon cord fabric and neoprene, operating pressure 150 PSIG at 220^{O}F through 12" size and operating pressure of 125 PSIG at 220^{O}F for sizes 14" through 24". Provide butyl or Hypolon liner and applications with fluid temperatures in excess of 225^{O}F.

B. Flexible connectors shall be single or twin sphere with Class 150 flange connections for sizes 2-1/2" and larger and threaded connections with galvanized female unions for sizes 3/4" through 2". Mason Industries MFTCR, Hyspan, Metra-Flex, Keflex, Proco, or equivalent. Flexible connectors required for outdoor installation shall be braided stainless steel type.

C. Installation of flexible connectors shall be in strict accordance with manufacturer's recommendations. Spacing between piping system flanges shall be based on the flexible connector's expanded length corresponding to the system's operating pressure. Control rods or cables shall be provided for units installed in unanchored applications where system operating pressure and dynamic forces exceeds manufacturer's recommendations for unrestrained installations.

D. For piping systems utilizing grooved pipe with mechanical couplings, flexible connectors consisting of a minimum of three (3) stacked couplings, equivalent to Victaulic Style 75, between 6" long grooved nipples may be substituted for the neoprene units specified herein.

2.14 PUMPS

A. End suction pumps: horizontal, end suction, frame mounted, flexibly connected cast iron bronze fitted with casing rings, 316 stainless steel shaft sleeves and mechanical seal. Casing shall have a minimum working pressure of 125 PSIG. Impeller shall be single suction enclosed type of bronze construction. Shaft shall be high strength 1045 carbon steel. Bearing frame shall be cast iron construction provided with catch basin reservoir with tapped drain hole to collect and pipe away mechanical seal leakage. Base plate shall be factory fabricated steel sufficiently rigid to support the ensemble and to keep the coupling aligned; baseplate shall be drip-lip design with tapped hole to pipe away leakage and condensation. Motors shall be high performance 5 hp and larger. Pumps

shall have mechanical seals. Furnish coupling guard. Allis Chalmers, Bell & Gossett, Aurora, Weinman, Peerless, Worthington, Armstrong, Dunham Bush, Pacific, Taco, or equivalent.

B. In-line recirculating pumps: Cast iron body, bronze fitted, with mechanical seal. Motor shall be 1750 RPM for use with 115 volt current. Bell & Gossett, Thrush, Taco, Armstrong, or equivalent.

2.15 EXPANSION TANK

A. Furnish and install diaphragm type, pre-pressurized, ASME code construction 125 PSIG working pressure, expansion tank in horizontal or vertical arrangement as shown on the drawing and required for equipment space allocation. Properly sized expansion tanks shall be provided for all closed circuit hydronic systems. Connect expansion tank to the low pressure side of the piping system with 3/4" minimum line size, provide quarter-turn ball valve with handle removed for manual isolation valve. Contractor shall field verify expansion tank air charge and re-charge as required to maintain correct system pressurization and tank expansion volume. Expansion tanks shall be Amtrol, Woods, Armstrong, Taco, or equivalent.

2.16 AIR/DIRT SEPARATOR

A. Furnish and install as shown on the drawings and schedule a full flow coalescing type dirt separator for the condenser water system. Selection shall be based upon system flow with pipe size as a minimum in accordance with the basis of design. In no case shall entering velocity exceed 10 feet per second. Separator shall be fabricated steel and rated for 150 psig working pressure. The vessel diameter and distance below the inlet / outlet connections must be equal to the basis of design. Unit shall include internal Spirotube® elements filling the entire vessel to suppress turbulence and provide minimum dirt separation efficiency of 80% of all particles 30 micron and larger within 100 passes. The elements must consist of a copper core tube with continuous wound copper wire medium permanently attached and followed by a separate continuous wound copper wire permanently affixed. A system strainer shall be installed upstream ahead of the dirt separator to catch all large material that may have been left in piping during construction. Include removable lower head for internal inspection.

B. Basis of design for the dirt separator shall be the Spirotrap® Series TDT or THT as manufactured by Spirotherm, Inc., Glendale Heights, Illinois or approved equal. [IM1]

2.17 WATER PRESSURE REGULATING VALVES

A. Furnish and install water pressure regulating valves, Watts U5B, Bell & Gossett, Amtrol, Cash, Jordan, or equivalent, 3/4" size minimum for water makeup to all hydronic systems and at other locations as shown on the drawings. Water pressure regulating valves shall be brass body, union inlet with integral strainers, 300 PSIG maximum working pressure, with built-in thermal expansion bypass.

B. For high water capacity applications provide Watts 2235B, Bell & Gossett, Amtrol, Cash, Jordan, or equivalent.

C. Provide high or low pressure range depending on application requirements. Set pressure shall be as shown on the drawings, or as required to provide a minimum system pressurization of 12 PSIG at the system's highest point for closed circuit hydronic systems, or as recommended by equipment manufacturers.

2.18 WATER PRESSURE RELIEF VALVES

A. Furnish and install ASME labeled, National Board Stamped, water pressure relief valves, Watts Series 174A or 740, Bell & Gossett, Amtrol, Cash, Jordan, or equivalent, 3/4" size minimum for relief of all water makeup to all closed circuit hydronic systems. Properly sized relief valves shall be provided where required for over-pressure protection on heat exchangers, converters, boiler, and pressure vessels, and other locations as shown in the drawings.

B. Relief valves shall be sized for the full system heating capacity, to match the makeup capacity, or as otherwise required to protect the system from over-pressure conditions. Relief valves shall be factory pre-set for maximum pressure rating shown in the drawings, or for approximately 125% of the system operating pressure, but in no case shall the relief valve setting exceed the maximum safe operating pressure of the system and system components and equipment.

2.19 WATER TEMPERATURE AND PRESSURE RELIEF VALVES

A. Furnish and install ASME labeled, National Board stamped water temperature and pressure relief valves, Watts, Cash, or equivalent, for all domestic water heaters, domestic water storage tanks, and other locations indicated in the drawings.

B. Water temperature and pressure relief valves shall be sized for the full system heating capacity at 210^{o}F maximum operating temperature and shall be furnished with the required valve thermostat tube extension length.

2.20 WATER REDUCED PRESSURE BACKFLOW PREVENTERS

A. Furnish and install water reduced pressure backflow preventer, as approved and accepted by the City of Las Cruces, State of New Mexico, Febco Model 825Y, Hersey, Beeco, Watts, or equivalent. 3/4" minimum size shall be provided for water makeup to all required HVAC systems. Backflow preventers shall be provided at other locations as shown on the drawings. Reduced pressure backflow preventer shall include two shut-off gate or ball valves, two check valves, pressure relief valve, and four test cocks. Units shall be factory assembled, tested and certified. Units 2" and smaller shall be brass body, threaded connections, 175 PSIG maximum working pressure. Units 2-1/2" and larger shall be provided with flanged connections.

B. Water reduced pressure backflow preventer installation shall be in accordance with manufacturer's instructions and City of Farmington, State of New Mexico requirements for access for testing and inspection.

C. See Division 22, for backflow protection associated with site water supply system.

D. See Division 22 for backflow protection associated with building domestic water supply system.

E. See Division 21 for backflow protection associated with building fire protection system.

F. Backflow protection devices associated with landscaping and irrigation systems shall be furnished and installed under the Site Work sections of these specifications.

2.21 WATER TREATMENT

A. Water treatment for hydronic systems shall be provided as listed on the equipment schedule, shown on the drawings, and specified under the applicable piping system Sections of this specification.

2.22 FLOW METERS AND INSTRUMENTATION

A. Water meters and instrumentation shall be furnished and installed as shown on the drawings and specified in Section 23 0900.

2.23 SOLENOID VALVES

A. Furnish and install electric solenoid valves as shown on the drawing and as required for the operation of the mechanical systems. Solenoid valves shall be 115 volt single phase, 60 Hz, two-way arrangement, two positions with normally open or normally closed arrangement as required of the application. Solenoid valves associated with safety protection of systems including freeze-protection, drain down, etc. shall be provided such that in the event of a power failure the system shall fail to a safe operating condition. Solenoid valves shall be as manufactured by ASCO, Armstrong, Honeywell, Metrex, or equivalent.

B. Furnish hazardous duty enclosure where required by the application.

2.24 FLOW SWITCHES

A. Furnish and install flow switches where required for protection and/or monitoring of mechanical equipment including water chillers, boilers pumps, etc. and as otherwise shown on the equipment schedule, and the drawings.

B. Flow switches shall be either paddle type or differential pressure type as required by the application and as shown on the drawings, except differential pressure type flow switches shall be utilized for water chillers and other applications where minor pressure fluctuation could cause nuisance tripping of equipment operation.

1. Paddle type flow switch shall be McDonnell and Miller Model FS7-4 Series, or equivalent designed for industrial duty, brass body and trim, 300 PSIG maximum working pressure, paddle size as required for application, single pole double throw switches, with electrical rating of 7.4 full load amps at 115 VAC. Provide hazardous duty enclosure where required by the application. Flow switches shall be installed in a horizontal pipe with inlet and outlet conditions necessary to provide trouble-free operation.
2. Differential pressure flow switch shall be Honeywell Model 406 Series or equivalent, adjustable pressure differential setting, dustproof mercury switch enclosure, 1/4" NPT bellows connections, single pole, single throw switch, with electrical rating of 7.2 full load amps at

115 vac. Differential pressure switches shall be properly supported on the equipment controlled or wall mounted adjacent to the equipment or piping system.

2.25 ELECTRICAL HEAT TRACING SYSTEM

A. Furnish and install electric heat tracing system for winterizing protection for all liquid piping systems exposed to the outdoor ambient environment and piping systems in the unheated areas of the building.

B. Heating cable shall be self-regulating rapid trace, Type SRL, low temperature, heating cable rated at 150°F maximum maintenance temperature and suitable for 185°F maximum exposure temperature, or type SRM medium temperature heating cable rated at 250°F maximum maintenance temperature and suitable for 375°F maximum exposure temperature, as required by the application and as manufactured by Chromolux or equivalent. Heating cable shall be flexible, parallel circuit construction consisting of a continuous self-limiting resistance, conducive inner core material between two parallel copper bus wire, designed for cut-to-length at the job site by the Contractor and suitable for wrapping around piping valves and complex fittings. Self-regulation shall prevent overheating and burnouts even where the cable overlaps itself. Provide end seals for ends of circuits. Wire at the ends of circuits shall not be tied together.

C. Heating Tracing System shall be furnished with all accessories required for the complete installation including the power supply connection fitting and stainless steel mounting brackets with stainless steel worm gear clamp to fasten bracket to pipe, 1/2 inch wide fiberglass reinforced pressure sensitive cloth tape as required to fasten cable to pipe at not greater than 12 inch intervals. Furnish pipe surface temperature control thermostat with capillary and copper bulb sensor, cast aluminum NEMA (water- tight) enclosure, 1/2 inch NPT conduit hub, SPST switch with required rating at 115 VAC through 5 KW systems capacity and 120 volt single phase, 60 HZ for system heating capacities in excess of 5 kW. Set thermostat to maintain pipe surface temperature at not less than 34°F. Furnish and install piping labels on systems with electric heat tracing, manufacturer's standard (NEC code), labeled or stamped "ELECTRIC TRACED" labels shall be installed on the insulation pipe jacket at 10 foot intervals along the pipe on alternating sides.

D. Electric Heat tracing system sizing shall be provided as recommended by the manufacturer to maintain pipe surface temperature at 34°F minimum during the winter outdoor design temperature of 0°F with 15 MPH wind velocity, and the normal system fluid operating temperature. See Section 230523, HVAC Insulation for insulation characteristics and thickness associated with electrical heat traced systems. Piping system insulation shall be oversized as required to accommodate the heating cable.

2.26 EXPANSION JOINTS

A. Furnish and install corrugated bellows expansion joint, Hyspan Series 1500, Metra-Flex, Keflex, Proco, Flexonics, or equivalent, self-equalizing, 150 PSIG working pressure at 850°F, Class 150 ASA flange connections 1-1/2" size and above, single or dual center base configuration as shown on the drawings, constructed of corrugated Type 304 or 321 stainless steel, ring controlled, with integral stainless steel or Monel sleeve, and removable carbon steel external housing to protect bellows and support insulation. Furnish limit rods to prevent expansion joint from exceeding rated travel. Joint design shall be for maximum flexibility over 10,000 cycles minimum.

B. Expansion joint sizing and installation shall be as shown on the drawing and as recommended by the manufacturer.

C. Expansion joints shall be insulated with flexible 2" minimum thickness of high temperature fiberglass blanket insulation furnished with joint and installed under the external protective housing.

D. Contractor shall carefully check expansion joint limit rods and make adjustments as required to ensure proper joint movement and operation.

2.27 EXPANSION COMPENSATORS

A. Furnish and install expansion compensators, Hyspan series 8500, Metra-Flex, Keflex, Proco, Flexonics, or equivalent, stainless steel laminated bellows with stainless steel or carbon steel shroud, 175 PSIG pressure rating at 250^0F, 2 inch straight line expansion and 1/2 inch contraction. Furnish copper tube with sweat ends for compensators installed in copper piping systems. Furnish standard wall carbon steel pipe tube for compensators installed in steel piping systems, threaded connectors for sizes 2" and smaller and Class 150 ASA flange connection for sizes 2-1/2" or larger.

B. Expansion compensators sizing and installation shall be as shown on the drawings and as recommended by the manufacturer.

2.28 PIPE ALIGNMENT GUIDES

A. Furnish and install factory fabricated steel pipe alignment guides, Hyspan Series 9500, Metra-Flex, Keflex, Proco, Flexonics, or equivalent, to maintain the longitudinal position of pipe centerline between expansion joints and compensators with axial restraint. Alignment guides shall consist of a bolted two-section outer cylinder and base with two-section guiding spider bolted tight to the pipe guide. Guide and spider shall be sized to clear pipe and pipe insulation and long enough to prevent over travel of spider and cylinder. Guides shall not be used for pipe support.

B. Alignment guides shall be arranged and installed as shown on the drawings and as recommended by the manufacturer.

2.29 PIPE ANCHORS

A. Pipe anchors shall be constructed of welded steel as detailed on the drawings. Pipe anchors shall be attached to the building structure in a manner approved by the Architect.

B. Pipe anchors shall be arranged as shown on the drawings and as required to properly control/piping system expansion and contraction in conjunction with system flexibility due to off-sets, bends, and loops and expansion joints and compensators.

PART 3 - EXECUTION

3.1 INSTALLATION

A. All specialties shall be installed in accordance with the best standard practices and as recommended by the manufacturer.

B. Where thermometers, gauges, vents and test fittings occur in insulated piping systems or on insulated equipment, extension necks shall be provided to extend beyond the insulation.

3.2 AIR VENTS

A. Manual air vents shall be installed as specified herein and at the high points in all piping systems.

B. Automatic air vents shall be installed as specified herein and at locations indicated on the drawings. Automatic air vents shall be installed level and in accordance with manufacturer's directions to properly vent system, complete with individual isolation valves.

3.3 STRAINERS

A. All strainer screens, including basket strainers and suction diffusers, shall be removed and cleaned prior to commencing testing and balancing work and shall be maintained clean through project final acceptance by the Owner. Suction diffuser start-up strainers shall be removed prior to final system testing and balancing work.

3.4 TEST AND ADJUSTMENT

A. Contractor shall field adjust all water pressure regulating valves, flow switches, water level controls, and specialties to provide required system operation.

B. Contractor shall field test and verify the operation of all safety devices including water relief valves and temperature and pressure relief valves.

3.5 RELIEF VALVE DISCHARGE

A. Water pressure relief valve and water temperature and pressure relief valve discharges shall be piped full size to the outside of the building or discharged indirectly in a properly sized building floor drain or floor sink, and as allowed by the Building Mechanical and Plumbing Codes. When the operating discharge temperature is in excess of 212^{o}F, the discharge shall be equipped with a splash shield or centrifugal separator.

B. Water reduced pressure backflow preventer discharge shall be piped full size to the outside of the building or discharged indirectly into a properly sized building floor drain or floor sink as allowed by the Building Mechanical and Plumbing Codes. Provide a bronze air gap funnel with stainless steel fasteners for installation under reduced pressure backflow prevention relief valve. Febco Model AGD or equivalent, 1" discharge pipe size for backflow preventer size through 2".

END OF SECTION 23 0505

SECTION 23 0523 - VALVES

PART 1 - GENERAL

1.1 REQUIREMENTS

A. All Valves shall conform with current applicable provisions of the General Conditions, Supplementary Conditions, and General Requirements.

B. All Valves shall meet the current MSS Specifications covering Bronze & Iron Valves. MSS-SP-80, MSS-SP-70, MSS-SP71, MSS-SP-85 where applicable.

C. Lead Ban: Valves shall be lead free. The term lead free is defined as valves which do not contain more than 8.0% lead.

1.2 RELATED SECTIONS

A. Section 23 0500 for Common Work Requirements for HVAC.

B. Section 23 0500 for Valve Identification.

C. Section 23 0504 for Pipe and Pipe Fittings.

D. Section 23 2119 for valves associated with underground pre-insulated piping systems.

E. Section 23 0900 for Automatic Temperature Control Valves.

F. Division 21, for fire suppression system valves and tamper switches.

G. Division 22, for plumbing system.

1.3 SCOPE

A. Contractor shall furnish and install all valves and accessories necessary for satisfactory operation of the systems.

1.4 VALVE REQUIREMENTS

A. All Gate, Globe, Check, Ball valves shall be manufactured by Milwaukee, Nibco, Apollo, Stockham, Powell, Crane, Grinnell, or equivalent.

B. All lubricated plug valves shall be as manufactured by Rockwell, Walworth, Homestead, or equivalent.

C. Butterfly valves shall be as manufactured by Milwaukee, W. C. Norris, Centerline, Crane,

Demco, Keystone, Grinnell, Victaulic, Nibco, or Dezurik, or equivalent. Butterfly valves may be used for closed circuit chilled water, heating hot water (200°F maximum) run-around coil and heat pump circulating water systems and for condensing water systems. Butterfly valves shall not be used for domestic water or other non-specified service.

D. Ball valves shall be utilized in lieu of gate valves and globe valves for all HVAC and plumbing systems for sizes 2" and smaller.

E. Butterfly valves may be substituted for gate, globe and ball valves for specified services, and for other services as may be approved by the Architect.

F. All valves furnish under Division 22 and 23, of the same type, shall be products of a single manufacturer unless otherwise approved by Owner's Representative.

G. Provide gate and globe valves with packing that can be replaced with the valve under full working pressure.

H. Provide chain operators for valves 4" and larger installed within mechanical equipment spaces where valves center line is in excess of eight feet above the floor or operating platform and as otherwise indicated on the drawings.

PART 2 - PRODUCTS

2.1 GENERAL SERVICE VALVES, HVAC AND PLUMBING SYSTEMS

A. Gate Valves - 2" and Smaller, Class 125: Valves 2" and smaller shall be cast of ASTM B-62 bronze, Class 125 construction, solid disc, rising stem, gland packed, non-asbestos packing. Milwaukee 148 (Threaded), or equivalent; Milwaukee 149 (Solder), or equivalent.

B. Gate Valves - 2" and Smaller, Class 150: Valves 2" and smaller shall be cast of ASTM B-62 bronze, Class 150 construction, solid wedge disc, rising stem, union bonnet, gland packed, non-asbestos packing. Milwaukee 1151 (Threaded), or equivalent; Milwaukee 1169 (Solder), or equivalent

C. Gate Valves - 2" and Smaller, Class 300: Valves 2" and smaller shall be cast of ASTM B-62 bronze, Class 300 construction, solid wedge disc, rising stem, union bonnet, gland packed, non-asbestos packing. Milwaukee 1184 (Threaded), or equivalent.

D. Gate Valves - 2-1/2" and Larger, Class 125: Valves 2-1/2" and larger shall be of ASTM A-126 Class B cast iron, flanged ends, Class 125 construction, OS & Y Type, rising stem, bronze trim, non-asbestos packing. Milwaukee F2885, or equivalent.

E. Gate Valves - 2-1/2" and Larger, Class 250: Valves 2-1/2" and larger shall be of ASTM A-126 Class B cast iron, flanged ends, Class 250 construction, OS & Y Type, rising stem, bronze trim, non-asbestos packing. Milwaukee F2894, or equivalent.

F. Globe Valves - 2" and Smaller, Class 125: Valves 2-1/2" and smaller shall be of ASTM B-62, Class 125 construction, bronze trim, gland packed, non-asbestos packing. Milwaukee 502 (Threaded), or equivalent; Milwaukee 1502 (Solder), or equivalent.

G. Globe Valves - 2" and Smaller, Class 150: Valves 2" and smaller shall be of ASTM B-62, bronze, Class 150 construction, bronze trim, composition disc, union bonnet, gland packed, non-asbestos packing. Milwaukee 590 (Threaded), or equivalent; Milwaukee 1590 (Solder), or equivalent.

H. Globe Valves - 2" and Smaller, Class 300: Valves 2" and smaller shall be of ASTM B-62, bronze, Class 300 construction, bronze trim, union bonnet, gland packed, non-asbestos packing. Milwaukee 572 (Threaded), or equivalent

I. Globe Valves - 2-1/2" and Larger, Class 125: Valves 2-1/2" and Larger shall be of ASTM A-126, Class B cast iron, flanged ends, Class 125 construction, bolted bonnet, gland packed, non-asbestos packing. Milwaukee F2981M, or equivalent.

J. Globe Valves - 2-1/2" and Larger, Class 300: Valves 2-1/2" and larger shall be of ASTM A-126, Class B cast iron, flanged ends, Class 300 construction, bolted bonnet, gland packed, non-asbestos packing. Milwaukee F2983, or equivalent.

K. Check Valves - 2" and Smaller, Class 125: Valves 2" and smaller shall be cast of ASTM B-62 bronze, Class 125 construction, Y-pattern, swing type design, teflon seat, disc for steam service, Buna-N for water service. Milwaukee 509 (Threaded), or equivalent; Milwaukee 1509 (Solder), or equivalent.

L. Check Valves - 2" and Smaller, Class 150: Valves 2" and smaller shall be cast of ASTM B-62 bronze, Class 150 construction, Y-pattern, swing type design, bronze seat, composition disc, teflon seat disc for steam service, Buna-N for water service. Milwaukee 510 (Threaded), or equivalent; Milwaukee 1510 (Solder), or equivalent.

M. Check Valves - 2" and Smaller, Class 300: Valves 2" and smaller shall be cast of ASTM B-62 bronze, Class 300 construction, Y-pattern, swing type design, bronze regrinding disc. Milwaukee 507 (Threaded), or equivalent.

N. Check Valves - 2 1/2" and Larger, Class 125: Valves 2-1/2" and larger shall be of ASTM A-126 Class B, cast iron, flanged ends, Class 125 construction, bolted bonnet, bronze trim, swing type design. Milwaukee F2974M, or equivalent.

O. Check Valves - 2 1/2" and Larger, Class 250: Valves 2-1/2" and larger shall be of ASTM A-126 Class B, cast iron, flanged ends, Class 250 construction, bolted bonnet, bronze trim, swing type design. Milwaukee F2970, or equivalent.

2.2 BUTTERFLY VALVES

A. Valves 2-1/2" and larger shall be full lug pattern, ASTM A-216, Class B cast iron body, 416-SS stems, aluminum/bronze disc, EPDM liner and seats (-30ºF to 275ºF) w/rigid phenolic cartridge, 200 PSIG working pressure with Bubble tight shut-off. Valves shall be for mounting between flanges with lugs drilled and tapped so that pipe may be disconnected on either side of valve with opposite end remaining under pressure. Milwaukee ML-123-E or equivalent.

B. Valves 4" and smaller shall be provided with level handler operator with spring loaded lock stops. Valves 5" and larger shall be furnished with manual gear operator with hand wheel.

C. Valves installed for insulated services shall be provided with extensions, as required, such that operator does not interfere with insulation or insulation jacketing.

D. Butterfly valves furnished for use in grooved piping system shall meet the material specification requirements as specified herein.

2.3 BALL VALVES

A. Valves 2" and smaller shall be cast of ASTM B-62 bronze, Class 150 construction, 600 PSI W.O.G. Two-piece body, chrome plated ball, blowout proof stem, reinforced TFE seats, non-asbestos packing. Milwaukee BA-100 (threaded) or equivalent. Milwaukee BA-150 (solder) or equivalent.

B. Valves installed on insulated services shall be provided with extensions, as required, such that operator does not interfere with insulation or insulation jacketing. Cutting or notching of the insulation or bending of handles shall not be permitted.

2.4 BALANCE VALVES

A. Valves 2" and smaller: Ball valve, bronze, Class 150 construction, 600 PSI W.O.G., Two piece body, Milwaukee BA-100 (threaded). Milwaukee BA-150 (soldered), as specified herein, or equivalent.

B. Valves 2-1/2" and larger: Lubricated plug valve, cast iron construction, 175 PSI W.O.G., Class 125 flange connections, level handle for valves 4" and smaller, manual gear operator with handle wheel for valve 5" and larger. Walworth No.1797F, or equivalent.

C. Valves 2-1/2" and larger:

1. Butterfly valve, full lug pattern, as specified herein.
2. Furnish level handle with infinite throttling positions and locking device for securing handle in any position for valves 4" and small and manual gear operator with hand wheel for valves 5" and larger.

D. Flow control and Flow Balance Valves: For calibrated flow balance valves and automatic flow control valves, see Specification Section 230505, Piping Specialties.

2.5 NATURAL GAS VALVES

A. Valves 3/4" and Smaller: Bronze natural gas cock, Walworth No. 590 (square head), Walworth 591 (flat head), or equivalent.

B. Valves 3" and Smaller: Ball valve shall be cast of ASTM B-584 bronze, Class 250 construction, threaded connections, chrome plated big ball and stem, RDTFE seat and stem packing, blow-out proof stem, UL Listed for natural gas service, Apollo 80-100 Series, or equivalent.

C. Valves 4" and Larger: Lubricated plug valve, cast iron construction, 175 PSIG W.O.G.,

threaded connection for valves 2" and smaller, Class 125 Flange connections, level handle operator. Walworth No. 1797F (Flanged), or equivalent.

2.6 MANUAL AIR VENTS AND DRAIN VALVES

A. For manual air vents and drain valves, see Specification Section 230505, Piping Specialties.

2.7 NON-SLAM SILENT CHECK VALVE

A. Check valves for pump discharge and other required non-slam silent operation, shall be center guided, suitable for vertical or horizontal installation position, cast iron in semi-steel body, bronze disc and trim, stainless steel spring, Buna-N seats, Class 125 or 250 construction, as required by the application, wafer or globe flanged pattern for valves 2" through 10" size and flanged pattern for valves 12" and larger. Milwaukee 1400 Series (wafer), or equivalent. Milwaukee 1800 Series (globe), or equivalent.

2.8 TRIPLE DUTY VALVE

A. At the Contractor's option, triple duty valve may be utilized at pump discharge in lieu of non-slam check valve and balance/shut-of valve, see Specifications Section 230505, Piping Specialties.

PART 3 - EXECUTION

3.1 INSTALLATION

A. All valves shall be installed in locations which will allow easy operation and facilitate maintenance.

B. Gate and Globe valves shall be installed with stems horizontal.

END OF SECTION 23 0523

SECTION 23 0549 - HVAC AND ELECTRICAL INSTALLATION COORDINATION

PART 1 - GENERAL

1.1 REQUIREMENTS

A. Conform with applicable provisions of the General Conditions, Supplementary Conditions and General Requirements.

1.2 RELATED DIVISIONS AND SECTIONS

A. Section 23 0500 for Common Work Requirements for HVAC.

B. Section 23 0900 for Facility Management System.

C. Division 1 and Section 230800, Commissioning for HVAC.

D. Division 26 for Electrical.

E. Division 26 for Building Fire Alarm.

1.3 SCOPE

A. It is the intention of this section to summarize the coordination of effort defined in the related sections and divisions of this specification.

B. If there is a conflict between this Section and other Sections and Divisions of this specification, this Section shall be the governing and decisive Section.

C. Make all connections to motors and controls for equipment supplied and/or installed under Division 23 according to Table 1 on the following page.

PART 2 - PRODUCTS

Not Applicable.

PART 3 - EXECUTION

3.1 INSTALLATION

A. No work shall be performed until the reviewed and marked submittal data have been reissued to the Contractor, unless written permission is obtained from the Architect.

TABLE 1

Item or System	Note	Supplied By (3)	Installed By (3)	Powered By	Control Field Wiring By
Equipment Motors		Div. 23	Div. 23	Div. 26	N/A
Motor Control Center Including Starters, Pilot Lights, Heater, Switches, Auxiliary Contacts, and Internal Control Wiring		Div. 26	Div. 26	Div. 26	Div. 23
Stand Alone Motor Starters (outside motor control centers)	(1)	Div. 26	Div. 26	Div. 26	Div. 23
Variable Frequency Drives (VFD's)		Div. 23	Div. 23	Div. 26	Div.23
Fused and Non-Fused Disconnects	(1)	Div.26	Div. 26	Div. 26	N/A
Control Relays & Control Transformers	(1)	Div. 23	Div. 23	Div. 26	Div. 23
Central Plant/Refrigeration Equipment Room Emergency Shutdown & Ventilation		Div. 23	Div. 23	Div. 26	Div. 23
Cooling Tower Vibration Switches		Div. 23	Div. 23	26	N/A
Boilers		Div. 23	Div. 23	Div. 26	Div. 23
Refrigeration Gas Monitor		Div. 23	Div. 23	Div.26	Div. 23
Kitchen Make-up System & Hood Exhaust Fans		Div. 23	Div. 23	Div. 26	Div. 26
Kitchen Exhaust Hoods & Lab Fume Hoods		Div. 23	Div. 23	Div. 26	N/A
Kitchen Hood Fire Protection System		Div. 23	Div. 23	Div. 26	N/A
Kitchen Hood Natural Gas Shut-Off Valve		Div. 23	Div. 23	Div. 26	N/A
Fan Coil Units Including, Return Air Dampers		Div.23	Div. 23	Div. 26	Div. 23
Water Chillers		Div. 23	Div. 23	Div. 26	N/A
Min. Outside Air Units Including Mixing Dampers		Div.23	Div. 23	Div. 26	Div. 23
Rooftop A/C Units Including Mixing Dampers		Div.23	Div. 23	Div. 26	Div.23
HVAC Unit Smoke Detectors		Div. 28	Div. 23	Div. 28	Div. 28
Fire/Smoke Control Dampers & Smoke Dampers		Div.23	Div. 23	Div. 26	Div. 28

Item or System	Note	Supplied By (3)	Installed By (3)	Powered By	Control Field Wiring By
Fan Coil Unit Condensate Float Switches		Div.23	Div. 23	N/A	Div. 23
Supply, Return & Exhaust Fan with unit mounted 115 VAC 2-position damper actuators interlock with fan motor/starter		Div. 23	Div. 23	Div. 26	N/A
Non-FMS Control Devices Including Wall Switches, Timers, Thermostats		Div.23	Div. 23	Div. 26	Div. 26
Chemical Treatment Systems		Div.23	Div. 23	Div. 26	N/A
Cooling Tower Sand Filter Units		Div. 23	Div. 23	Div. 26	N/A
Facility Management System (FMS)	(2)	Div.23	Div. 23	Div. 23	Div. 23
Facility Management System - Light Controls		Div. 26	Div. 26	Div. 26	Div. 26
Fire Alarm System & Interface w/HVAC System		Div. 28	Div. 28	Div. 28	N/A

TABLE NOTES:

1. Unless specified to be supplied with the equipment
2. Division 26 shall provide 120 VAC power to each mechanical space and the central plant as indicated on the drawings. Any additional power, transformers, and distribution shall be provided by the Section or Division indicated.
3. Division 23 indicates the HVAC contractor or their designated representative including equipment suppliers, sub-contractors, etc.

END OF SECTION 23 0549

SECTION 23 0550 - VARIABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.1 REQUIREMENTS

A. Conform with applicable provisions of the General Conditions, the Special Conditions, and General Requirements.

1.2 RELATED SECTIONS

A. Section 23 0500 for Common Work Requirements for HVAC.

B. Section 23 3000 for HVAC Air Distribution Systems and Equipment.

C. Section 23 0593 for Testing, Adjusting and Balancing.

D. Section 23 0900 for Facility Management System.

E. Division 22, Section 22 0550 for plumbing variable frequency drives.

1.3 GENERAL

A. Variable frequency drives shall be coordinated with the equipment being furnished and the wiring coordinated with the Division 26 contractor.

B. Do not connect power factor correction devices in the electrical circuit serving any variable frequency drive or the motor downstream of the drive.

C. All associated equipment motors shall be inverter duty in compliance with standard NEMA MG 1 Part 31 to ensure the compatibility between the VFD and motor.

D. Manufacturer's Qualifications: Firms regularly engaged in manufacture of variable speed ac motor drives of types and ratings required, whose products have been in satisfactory use in similar service for not less than five years. All Division 23, HVAC and Division 22, Plumbing variable frequency drives shall be of one manufacturer/model series and be provided by the exclusive local representative for sole source responsibility of all aspects of sales, startup, service, training and warranty.

E. Variable frequency drives shall be manufactured by Asea Brown Boveri (ABB), Series ACH 550, Magnetic, Reliance, or equivalent.

F. Substitutions must have Consulting (Mechanical/Electrical) Engineer written approval two (2) weeks prior to date of bid. Written approval does not relieve supplier of specification requirements. All clarifications and/or exceptions to this specification shall be submitted in writing to the Consulting Engineer at that time.

1.4 SUBMITTALS

A. Refer to Sections 23 0500 for additional requirements.

B. Product Data: Submit manufacturer's data including catalog information, performance data efficiency, harmonic distortion, RFI/EMI (Radio Frequency Interference/ Electromagnetic Interference) specifications, installation instructions and general recommendations for each type or size of motor.

C. The VFD manufacturer shall provide calculations as part of the shop drawing submittal specific to this installation, showing total harmonic voltage distortion is less than 5%. Input line filters shall be sized and provided as required by manufacturer to ensure compliance with IEEE Standard 519-1992, "Guide for Harmonic Control and Reactive Compensation for Static Power Converters."

D. The manufacturer furnishing the variable frequency drives shall be responsible for noise created by VFD's and/or motors. The manufacturer shall submit his noise test data based on the following: Sound power level at any speed output of the VFD, measure 3 ft. from the motor, shall not exceed 1.2 times the sound power level of the motor running in bypass mode with 60 Hz incoming line power. Measurements shall be recorded at 10 (minimum) different operating speeds.

E. Shop Drawings: Submit dimensioned drawings of cabinet and front panel layout, showing accurately scaled switches, their layouts and proximity to associated equipment. Furnish control schematic connection diagram showing all field connections.

1.5 SCOPE

A. Furnish and install pulse width modulating (pwm) output wave HVAC Variable Frequency Drives (VFD) and control wiring between the VFD control system as specified in Section 23 0550.

B. The Variable Frequency AC Motor Drive shall be designed to convert the 460 volt with a tolerated voltage window ± 30%, 3 phase, 60 Hz input power to 0 to 460 volt, 3 phase, 0-60 Hz variable frequency output power. The output frequency and voltage of the drive shall be variable such that a constant volts/Hz ratio is maintained throughout the operating range. The volts/Hz ratio shall be adjustable.

C. The drive shall be capable of operating any standard "off-the-shelf," NEMA B Design, squirrel cage induction motor with a 1.15 SF. The full load amp rating of the drive, adjusted as required for jobsite elevation and ambient conditions, shall be not less than 5% greater than the FLA rating of the motor or VFD must be oversized.

D. For maintenance purposes, the drive shall be capable of starting, stopping, and running with stable operation with the motor completely disconnected (no load).

E. Equipment will be designed and manufactured in accordance with applicable current NEMA, IEEE Standard 519-1992, (IEEE Guide for Harmonic Content and Control), UL 508, ISC 6 Enclosures for Industrial Controls and Systems, and IEC 801-2, 801-4, 255-4 recommendations and be designed for installation per NEC. Equipment will have UL, CUL, or ETL Listing or CSA listing as approved and accepted by the state and local code authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 VARIABLE FREQUENCY DRIVES

A. Each VFD shall be of the pulse width modulating design and shall consist of:

1. A full-wave diode bridge rectifier to convert incoming fixed voltage/frequency to a controlled DC voltage.
2. A DC bus filter with a power factor of .95 or better over the entire speed range.
3. The drive efficiency shall be 97% or better at full speed and full load. Efficiency shall not be less than 80% at 50% speed and load.
4. An inverter section to change the controlled DC voltage to a PWM adjustable voltage/frequency output for complete motor speed control. The inverter output will be generated by power transistors which will be controlled by six identical base driver circuits.

B. The VFD shall include the following:

1. The unit enclosure shall be NEMA Type 1, metal cabinet with front hinged access doors allowing access to all internal electric connections. Any VFD's mounted inside an equipment room with unducted return air and/or mounted in AHU (air handling unit) shall be furnished with NEMA type enclosure required by the local Construction Codes. All VFD's shall be UL Listed as plenum rated.
2. Electronic switching components shall be insulated gate/bipolar transistors, (IGBT).
3. An externally operated, door interlocked, fused disconnect switch or circuit breaker shall be provided. The base VFD shall be UL Listed with a short circuit interrupting rating of 100,000 symmetrical amps minimum without the need for input fuses. The DC Buss output shall be fused separately or electronically protected, with a indicating pilot light.
4. An internal 115V AC control power circuit with transformer and protective fuses shall be included or 250 mA of 24 VDC auxiliary power and be capable of loop powering a transmitter supplied by others.
5. Provide solid state relay interface for remote start/stop in both VFD and bypass mode independent of safety circuits.
6. Low frequency/low voltage start with linear adjustable ramp up to pre-selected speed.
7. Controlled acceleration and deceleration, separately adjustable, shall be provided from 2 to 180 seconds with torque limit override acceleration protection, and regeneration protection.
8. Critical Frequency lock out to skip over frequencies that may cause unstable operation in equipment being controlled. Provide at least three separate lockout settings.
9. The VFD 'run permissive circuit' will provide a normally open contact whenever a run command is provided (local or remote start command in VFD or bypass mode). The VFD system (VFD or bypass) shall not operate the motor until it receives a system ready command/contact closure.
10. Furnish line reactors/inductors with minimum 5% impedance designed to provide proper protection of harmonics and transients for the drive input power line. This is a minimum requirement and the manufacturer shall furnish higher rated line reactors or isolation transformers as may be necessary to maintain specified maximum total harmonic voltage distortion. Line reactors/transformers shall be factory mounted and wired within VFD enclosure. The 5% impedance reactors may be from dual (positive and negative DC bus)

reactors, or 5% impedance AC line reactors. VFD's with only one 5% DC reactor shall add AC line reactors.

11. EMI / RFI (Radio Frequency Interference/Electromagnetic Interference) filters. All VFD's shall include EMI/RFI filters onboard to allow the VFD assembly to be CE marked and meet product Standard EN 61800-3 for the First Environment restricted level.
12. All components must be accessible from the cabinet door for service. The control shall be microprocessor based and the control card shall be the same part number and fully interchangeable for all ratings and voltages of VFDs.
13. Drive must be designed for against the wall and/or floor mounted arrangements, as required by the project installation requirements.
14. The drive shall be software programmed to provide automatic restart after a power outage or trip from overcurrent, over voltage, under voltage or over temperature. A delay shall occur before restart to allow motor to stop completely. The drive shall shut down and shall require manual restart if the automatic reset/restart function is not successful within 3-5 attempts within a short time period.
15. The VFD shall be capable of starting into a rotating load (forward or reverse) and accelerate or decelerate to setpoint without safety tripping or component damage (flying start). The VFD shall include a fireman's override input. Upon receipt of a contact closure from the fireman's control station, the VFD shall override all other inputs (analog/digital, serial communication, and all keypad commands) and force the motor to run at the adjustable, preset speed.
16. The VFD shall be equipped with an automatic extended power loss ride-through circuit which will utilize the inertia of the load to keep the drive powered. Minimum power loss ride-through shall be one-cycle, based on full load and no inertia. Removing power from the motor is not an acceptable method of increasing power loss ride-through.
17. Furnish terminal strip for external interlocks, isolated from the line and ground.
18. Furnish prewired keypad with 3-position HAND-OFF-AUTO switches/buttons and manual speed control that will incorporate "bumpless transfer" of speed reference when switching between "HAND" and "AUTO" modes. When in "HAND," the VFD will be started, and the speed will be controlled from the manual speed control. When in "OFF," the VFD will be stopped. When in "AUTO," the VFD will start via an external contact closure, and its speed will be controlled via an external speed reference.
19. The drive shall employ three (3) current limit circuits to provide trip-free operation:

    a. The Slow Current Regulation limit circuit shall be adjustable to 125% (minimum) of the VFD's variable torque current rating. This adjustment shall be made via the keypad, and shall be displayed in actual amps, and not as percent of full load.

    b. The Rapid Current Regulation limit shall be adjustable to 170% (minimum) of the VFD's variable torque current rating.

    c. The Current Switch-Off limit shall be fixed at 255% (minimum, instantaneous) of the VFD's variable torque current rating.
20. The overload rating of the drive shall be 110% of it's variable torque current rating for one (1) minute every 10 minutes, and 140% of it's "H" torque current rating for two (2) seconds every 15 seconds.
21. The VFD shall have door interlocked thermal magnetic circuit breaker which will disconnect all input power from drive and all internally mounted options when bypass is required. The disconnect handle shall be thru-the-door type, and be padlockable in the OFF position.
22. The VFD shall have input line fuses mounted in drive enclosure.

23. The VFD shall be optimized for a 3 kHz carrier frequency to reduce motor noise. The carrier frequency shall be adjustable by the start-up engineer. VFD shall reduce the carrier frequency based on actual VFD temperature that allows the highest carrier frequency without derating the VFD.
24. The VFD shall have a programmable digital operators keypad located in the front door of the drive enclosure which shall include the following features and requirements.
25. All VFDs shall have the same customer interface, including digital display, keypad and customer connections; regardless of horsepower rating. The keypad is to be used for local control (START/STOP, FORWARD/REVERSE, and speed adjust), for setting all parameters, and for stepping through the displays and menus.
26. A VFD mounted transfer switch motor selection option shall be provided to allow the operator to manually transfer between two motors. Interlocking shall be provided to prevent switching of the drive while operating. Use of external motor starters shall not be allowed.
27. The VFD shall give the user the option of either 1) displaying a fault, or 2) running at a programmable preset speed or last speed known if the input reference (4-20 mA or 2-10V) is lost; as selected by the user.
28. The VFD's shall utilize plain English digital display (code numbers are not acceptable). The digital display shall be a 40-character (2 line X 20 characters/line) LCD display. The LCD shall be backlit to provide easy viewing in any light condition. The contrast should be adjustable to optimize viewing at any angle. All set-up parameters, indications, faults, warnings and other information must be displayed in words to allow the user to understand what is being displayed without the use of a manual or cross-reference table.
29. There shall be a built-in time clock used to date and time stamp faults and record operating parameters at the time of fault. The clock shall also be programmable to control start/stop functions, constant speeds and four (4) separate, independent timer functions that have both weekday and weekend settings.
30. The VFD's shall utilize pre-programmed application macro's specifically designed to facilitate start-up. The digital keypad shall be removable, capable of remote mounting and uploading/downloading parameters and HVAC specific Application Macros that shall provide one (1) command to reprogram all parameters and customer interfaces for a particular application to reduce programming time and initial start-up of multiple VFDs.
31. The VFD shall have a manual speed control integral to the keypad.
32. Analog meter - output percent of maximum speed.
33. VFD shall have RS-485 port. The standard protocols shall be Modbus RTU, Johnson Controls N2 bus, Siemens Building Technologies FLN and BACnet available. No additional hardware, firmware, gateways, etc., shall be required for these standard protocols. Optional protocols for Lon Works, Profibus, Ethernet, and DeviceNet shall be available, and have the protocol in each VFD. The use of third party gateways and multiplexers is not acceptable.
34. All protocols shall be "certified" by the governing authority, non-certified protocols are not allowed. If additional gateway, hardware, etc., is required to obtain the BACnet, Modbus, etc., interfaces, the VFD manufacturer shall supply one (1) gateway, hardware device, etc., per VFD. Multiple VFD's sharing one (1) gateway, hardware, etc., shall not be acceptable.
35. BACnet connection shall be an RS485, MSTP interface operating at 9.6, 19.2, 38.4, or 76.8 Kbps. The connection shall be tested by the BACnet Testing Labs (BTL) and be BTL Listed. The BACnet interface shall conform to the BACnet standard device type of an Applications Specific Controller (B-ASC). The interface shall support all BIBBs (BACnet Interoperability Building Blocks) defined by the BACnet standard profile for a B-ASC.

36. All wires to be individually numbered at both ends for ease of troubleshooting.
37. The following operation information displays shall be standard on the VFD digital display. The display shall be complete English words (alpha-numeric codes are not acceptable):
38. Output Frequency

    a. Motor Current
    b. Calculated Motor Torque
    c. Calculated Motor Power
    d. DC Bus Voltage
    e. Output Voltage
    f. Heatsink Temperature
    g. Analog Input Values
    h. Keypad Reference Values
    i. Elapsed Time Meter
    j. kWh Meter

C. The drive shall have the following field adjustments:

1. Five (5) programmable critical frequency lockout ranges to prevent the VFD from continuously operating an unstable speed.
2. PID setpoint controller shall be standard in the drive, allowing a pressure or flow signal to be connected to the VFD, using the microprocessor in the VFD for the closed loop control. There shall be an independent, second PID loop that can be utilized to maintain setpoint of an independent process (i.e. valves, dampers, cooling tower bypass valve control, chilled water valve control, etc.
3. Two (2) programmable analog inputs shall accept a current or voltage signal for speed reference, or for reference and actual signals for PI controller. Analog inputs shall include a filter; programmable from 0.01 to 10 seconds to remove any oscillation in the input signal. The minimum and maximum values (gain and offset) shall be adjustable within the range of 0 - 20 mA and 0 - 10 volts. Additionally, the reference must be able to be scaled so that maximum reference can represent a frequency less than 60 Hz, without lowering the drive maximum frequency below 60 Hz.
4. Six (6) programmable digital inputs for maximum flexibility in interfacing with external devices.
5. Two (2) programmable analog outputs proportional to frequency, motor speed, output voltage, output current, motor torque, motor power, DC bus voltage, or active reference.
6. Three (3) programmable digital relay outputs. The relays shall be rated for maximum switching current 8 amps at 24 VDC and 0.4 amps at 250 VAC; maximum voltage 30 VDC and 250 VAC; continuous current rating 2 amps RMS. Outputs must be true form "C" type contacts; open collector outputs are not acceptable.
7. Two (2) independently adjustable accel and decel ramps. These ramp times shall be adjustable from 1 to 1800 seconds.
8. Two (2) independently adjustable accel and decel ramps. These ramp times shall be adjustable from 1 to 1800 seconds.
9. The VFD shall ramp or coast to a STOP, as selected by the user.

D. Speed Command Input shall be via:

1. Keypad or manual speed control as selected by user.

2. Two (2) analog inputs, each capable of accepting a 0-20mA, 0-10V, 2-10V signal. Input shall be isolated from ground, and programmable via the keypad for different uses.
3. Analog inputs shall have a programmable filter to remove any oscillation of the reference signal. The filter shall be adjustable from 0.01 to 10 seconds. The analog input should be able to be inverted, so that minimum reference corresponds to maximum speed, and maximum reference corresponds to minimum speed. The minimum and maximum values (gain and offset) shall be adjustable within the range of 0-20mA and 0-10 volts.
4. Floating point input shall accept a three-wire input from a Dwyer Photohelic, or equivalent type instrument.

2.1 USER SELECTABLE AUTOMATIC/MANUAL BY-PASS

(Operation of motor at full voltage at 60 Hz fixed speed).

A. Input line fused disconnect (service switch) and/or fast acting fuses exclusive to the VFD will allow the VFD to be disconnected from the line prior to clearing ups tream branch circuit protection to maintain bypass capability. Door inter-locked, pad-lockable circuit breaker will disconnect all input power from the drive and all internally mounted options, together with fully rated magnetic motor starters mechanically interlocked shall be used to transfer motor to line power. Transfer must occur in orderly fashion causing no component damage to either drive or motor. Manual bypass circuitry must be integral part of drive cabinet. Separate bypass or starter enclosure is not acceptable. The VFD shall be UL Listed by the drive manufacturer and UL508 label complete bypass assembly.

1. An output contactor, bypass contactor and VFD only disconnect/service switch and/or fuses will be provided. Overload protection shall be provided in both drive and bypass modes.
2. Provide user selectable manual or automatic bypass.
3. Bypass designs that incorporate fuses common to both the VFD and the bypass will not be accepted. Three contactor bypass schemes are not acceptable, as a VFD input contactor is not a NEC recognized, lockable, physical disconnect and is an unacceptable means of safely disconnecting power to VFD.
4. The drive / bypass shall provide single-phase motor protection and under-voltage protection of bypass, contactor coils, etc., shall be in both the VFD and bypass modes.
5. The following operators shall be provided:

    a. Bypass HAND-OFF-AUTO
    b. Drive mode selector
    c. Bypass mode selector
    d. Bypass fault reset

6. Dedicated digital input that will transfer motor from VFD mode to bypass mode upon dry contact closure for fireman's override. Two modes of operation: One mode forces the motor to bypass operation. The second mode as above also defeats all safeties and inputs (run until destruction).

B. Furnish auxiliary contacts to monitor drive status with FMS. A drive failure of any kind shall produce alarm signal and FMS.

PART 3 - EXECUTION

3.1 INSTALLATION

A. The drive shall be installed in strict accordance with manufacturer instructions. A minimum of 42" clearance shall be maintained in front of drives.

3.2 EQUIPMENT PROTECTION

A. Whenever possible drive shall be mounted within sight of motor that is controlled by drive. In the event that drive is not mounted within sight of motor, a disconnect will be installed (under Division 26) within sight of motor. If a disconnect is installed between motor and drive the drive supplier shall provide a 6" x 6" red engraved warning sign to be mounted at the disconnect which shall read as follows:

"WARNING: TO AVOID DAMAGE TO FREQUENCY DRIVE DO NOT PULL DISCONNECT, EXCEPT IN AN EMERGENCY, UNTIL FREQUENCY DRIVE IS SHUTDOWN."

B. Drive shall include a coordinated AC transient protection system consisting of MOV's (Metal Oxide Varistors: phase-to-phase and phase-to-ground), a capacitor clamp, and 5% impedance reactors designed to protect itself against all normal transients and surges in the incoming power line, any grounding or disconnecting of its output power, and any interruption or run away of the incoming speed reference signal. Protection is defined as a normal shutdown with no component damage.

C. In general the drive shall contain the following protective circuits. In the case of a protective trip, the drive shall STOP, and announce the fault condition in complete words (alpha-numeric codes are not acceptable).

1. Overcurrent trip 200% of the VFD’s variable torque current rating.
2. Overvoltage trip 130% of the VFD’s rated voltage.
3. Undervoltage trip 60% of the VFD’s rated voltage.
4. Ground Fault.
5. Adaptable Electronic Motor Overload (I^2t). The electronic motor overload protection shall protect the motor based on speed, load curve, and external fan parameter. Circuits which protect the motor only at full speed are unacceptable.

3.3 OPERATING CONDITIONS

A. +/- 10% line voltage variations.

B. 5% incoming line frequency variations.

C. Maximum output frequency variations shall be +/- .25%.

D. FLA to meet or exceed UL/NEC table 430-150 of the minimum motor horsepower specified on the equipment schedule on the drawings.

E. Ambient temperature.

1. 0 to 50^{O}C - NEMA 1 and 12 indoor enclosures: 1 thru 50 HP, 480 & 230 volt shall be capable of continuous operation as per VFD manufacturers documented/submittal data or VFD musts be oversized.
2. 0 to 40^{O}C - NEMA 1 and 12 indoor enclosures: 60 thru 550 HP, 480 & 230 volt, shall be capable of continuous operation; From 49 to 50 Deg. C (104 to 122 Deg. F.), VFD current de-rate as per VFD manufacturers documented/submittal data or VFD must be oversized.
3. 0 to 50^{O}C - NEMA 3R outdoor enclosures inclusive of all HP and voltages shall be capable of continuous operation as per VFD manufacturers documented/submittal data or VFD must be oversized.

F. Altitude.

1. 0 to 3300 feet above sea level without deration.
2. Derate per manufacturer’s recommendation for project elevations above 3300 feet.

G. 90% Maximum humidity (non-condensing).

3.4 TESTING AND DOCUMENTATION

A. Manufacturer to conduct standard factory tests to assure compliance with specification requirements.

B. Manufacturer's local Designated Service Station's startup technician shall provide field startup and commission of all VFDs and shall demonstrate trouble free, stable operation for conditions of starting, full load, three quarter load, half load, quarter load, no load and intermediate loads. The local Designated Service Station shall have factory trained and certified applications engineer/service personnel to provide service, training and warranty onsite 24/365 (24 hours / 365 days per year) and a toll-free support line. Provide four (4) hours onsite training of programming and operation.

C. Field tests shall include 100 hours of operation under load to demonstrate adequacy of equipment under thermal and voltage stresses, and that harmonic and other interferences do not adversely affect the electrical instrumentation and communications systems.

D. Manufacturers technically qualified and factory trained representative to make final written documents of installation, inspection and test run.

E. Field testing to include demonstration of automatic restart under operation of the following existing controls:

1. Fire Alarm.
2. Nitestat.
3. OFF/AUTO Switch.
4. Clock Control.
5. FMS START/STOP in both VFD and BYPASS MODE.

F. Switching from bypass to VFD operation both manually and automatically which shall be user selectable.

G. Complete records of test procedure and results to be made available at no additional cost to purchaser's representative.

H. Equipment shall carry a two (2) year guarantee as to workmanship, material, and satisfactory functioning from date of startup or maximum of 30 months from date of shipment from factory.

I. Furnish complete sets of their drawings showing control schematics, transistor schematics, wiring, outline dimensions, mounting details and equipment weight.

J. Operating & Maintenance Data and Spare Parts List: Furnish copies of all instruction books, spare parts lists and special bulletins covering on-site installation and operation in accordance with Section 23 0500.

END OF SECTION 23 0550

SECTION 23 0593 - TESTING, ADJUSTING AND BALANCING OF MECHANICAL SYSTEMS

PART 1 - GENERAL

1.1 GENERAL

A. Conform with applicable provisions of the General Provisions and the General Requirements.

B. Testing, adjusting and balancing (TAB) shall be performed by a TAB Agency which is independent of the Mechanical Contractor.

C. The TAB Agency's efforts shall be paid for by the Contractor and included in the mechanical contract price.

D. Unless specifically noted, all work specified in this section shall be included in the scope of the TAB Agency's work. But some work described in this section is to be performed by the mechanical contractor, controls contractor, or others, and that work is specifically noted to be by these entities.

1.2 SCOPE

A. Provide TAB for the systems and equipment installed under Division 23, including but not limited to:

1. Supply and exhaust air systems including process and kitchen systems.
2. Return air where specifically noted.
3. Hydronic systems including domestic HW return systems.

B. Provide all labor, instruments, and tools necessary to test, adjust and balance the systems shown on the drawings and/or described in these specifications. Check equipment performance, take measurements, adjust systems and equipment to provide specified performance, and report results. Submit reports to keep all parties posted on the progress of the TAB work.

C. Where the TAB effort indicates deficiencies in system performance, TAB Contractor shall take the lead in a collaborative effort to trouble-shoot and resolve these deficiencies. Engage the assistance of others where necessary, starting with the Mechanical Contractor and Controls Subcontractor. Take additional measurements as required to identify the cause of the deficiencies, perform additional TAB as required to bring the system in compliance with the design intent. Engage the assistance of the Engineer and others where necessary. Indicate final setpoints and readings in a final TAB report.

D. Include three days of effort on site for tests and/or balancing as directed in writing by the Owner's Representative beyond that described herein, but prior to substantial completion.

E. Include two days on site for TAB efforts as directed in writing by the Owner's Representative after substantial completion.

1.3 STANDARDS AND DEFINITIONS

A. Perform all work in accordance with these specifications and the latest edition of the NEBB Standards.

B. Air Handling Unit: Where the term Air Handling Unit (AHU) is used in this spec section, it shall include any factory fabricated or field erected unit that includes a fan and other components which filter, heat, cool, humidify or dehumidify the air stream. But the term AHU, where used in this section, does not include fan powered terminal units, fan coil units, unit heaters, cabinet unit heaters, etc.

C. Air Handling System: A fan or AHU and ductwork.

D. Hydronic System: A system in which a liquid is used to convey heat.

E. Record or Report: Where used as a verb, these terms mean to include in the TAB report.

1.4 QUALIFICATIONS

A. TAB agencies shall meet the following qualifications:

1. Membership in the Associated Air Balance Council (AABC), National Environmental Balance Bureau (NEBB) or the Testing, Adjusting and Balancing Bureau (TABB).
2. An office located within a 100 mile radius of the project site.
3. A minimum of five (5) years experience in the TAB field.

B. The following TAB Agencies are prior approved:

NEW MEXICO

1. Energy Balance & Integration
2. Kirk Air Co.
3. Native Air
4. N-Demand Test and Balance LLC
5. Air Moving Equipment Company

ARIZONA

1. Technical Air Balance
2. Arizona Air Balance
3. Precisionaire

1.5 SUBMITTALS

A. Mechanical Contractor shall submit the name of the proposed TAB agency prior to the TAB agency performing any services.

1. Submit a list of proposed personnel, including resumes with related project experience and certifications.
2. Submit proposed TAB procedures, instrumentation and measurement equipment including calibration data, and proposed sample TAB report forms.

B. Pre-Construction Report: Prior to the Mechanical Contractor installing the systems, the TAB Agency shall submit a letter indicating whether the design includes all devices the TAB Agency will need to successfully perform the TAB work. If any additional balancing devices are

needed, the TABB Agency shall so note this in the pre-construction report.

C. **[Pre-Construction Test: Measure and report system air [and water] flows and equipment performance prior to any demolition or new construction work.]**

D. Submit TAB reports as noted herein. Reports shall be in both hard copy and PDF format.

1.6 TAB PREPARATION AND COORDINATION

A. Mechanical Contractor shall perform the following in a timely fashion:

1. Provide the TAB Agency with the project documentation (drawings, specifications, bulletins, submittals, shop drawings, etc.) necessary to perform the TAB services.
2. Install, fill, pressure test, start up, clean, and the vent systems to be tested and balanced.

B. Controls Subcontractor shall perform the following in a timely fashion:

1. Install and make operational all necessary control systems and equipment, including computers and computer programs.
2. Provide qualified personnel to operate the systems as necessary to support the TAB effort. Provide the TAB contractor with the computer software necessary to facilitate the TAB effort.
3. Assist as required to resolve problems which become evident due to TAB work, and as required to obtain specified system performance.

PART 2 - PRODUCTS

2.1 EQUIPMENT

A. Provide all equipment and instruments necessary to perform the work specified herein. Calibrate and maintain instruments per NEBB Standards. Provide not less than the following:

1. Pitot tubes and draft gauges.
2. Flow hood.
3. Velometer.
4. Thermometers.
5. Pressure gauges.
6. Flow meter test kit.
7. Ampere – voltmeter.
8. Speed indicator.
9. Sound meter to measure eight octave bands.

PART 3 - EXECUTION

3.1 GENERAL

A. Review and inspect the mechanical systems for conformance with design documents. Test, adjust and balance all system flows under design conditions and under other conditions where part load testing is specified. Comply with measurement tolerances per NEBB. Balance to within 10% of design flows unless otherwise specified.

B. Visually mark the final settings of balancing dampers, balancing valves, fan speed controls, etc.

C. Comply with NEBB Standards. The descriptions included herein are a guide to the minimum information needed.

D. Troubleshooting: In the event that any areas fail to get proper flow, take the lead in troubleshooting the system. Measure pressures, flows, etc. at various points throughout the systems as required to identify the cause of the deficiencies and identify upgrades which will resolve these deficiencies. Coordinate any remedial efforts directly with mechanical and controls contractors and re-test as required.

3.2 TEST AND BALANCE REPORT

A. Report shall be 8-1/2" x 11" bound into a complete and coherent report, except that drawings may be larger size, but still bound into the report. All forms shall be typewritten or legibly handwritten.

B. Include the following sections in the order indicated:

1. Cover sheet with the Project Name, Location, and the names of the Mechanical Contractor and Engineer
2. Table of Contents
3. Summary indicating the highlights of the report and summarizing any deficiencies and recommendations
4. Test results including the names of the persons performing the tests and dates the tests were performed
5. Drawings
6. Description of the test procedures used
7. List of instruments used along with their calibration data
8. Qualifications of personnel

C. Submit five copies and a PDF of the complete TAB report minimum two weeks before the first O&M instruction session. One copy will be returned to the Contractor with review comments.

3.3 BASIC AIR HANDLING SYSTEM TESTING, ADJUSTING AND BALANCING

A. General

1. Test all fans and air handling systems. Balance systems to achieve specified air flows

while minimizing throttling losses.

2. Air Flow Measurements: Fan and AHU flow rates may be determined by pitot tube traverse or by measuring fan speed, suction and discharge pressures, and comparison with the fan curve. Measure duct air flows using pitot tube traverses. Measure air flows of grilles, registers and diffusers using either capture hoods or pitot tube traverses in the connected ductwork. Make such other tests as may be required to demonstrate that systems perform per the design requirements.
3. Air Flow Measuring Stations: Calibrate each air flow measuring station which is provided as part of the construction contract. Use duct pitot tube traverses or other appropriate means to measure air flows. Coordinate with the flow measuring station supplier, and enter calibration coefficients into the FMS. Record the results of this effort.
4. Alert Mechanical Contractor and Engineer if any fan or air handling unit (AHU) appears to be operating in an improper or unsafe condition.
5. Seal all test holes in ductwork once testing is complete. Repair insulation jackets to maintain the integrity of the vapor barrier.
6. Include in the report copies of ductwork drawings with test points indicated.
7. Variable Flow Systems: Verify proper fan tracking from full flow to 50% flow.

B. Fans: Perform the following for all fans, including those provided as part of an AHU.

1. Fan Nameplate: Record unit number per the equipment schedule, manufacturer, model, size, and serial number.
2. Performance Data: Measure air flow and adjust fan speed to achieve required flow. Record air flow, static pressure rise and fan speed.

    a. Advise when belt and/or sheave changes are required to achieve the design flows. Mechanical contractor shall make the necessary changes as part of the mechanical contract. Approximately 25% of fans may require a sheave and/or belt change.

3. Current and Voltage: Record motor nameplate and measured voltage and amperage. Advise if motor amps exceed rated load amps.

C. Air Handling Units:

1. Outside Air: Test outside air flows using a pitot tube traverse and balance as required. If a traverse is not practical, use the mixed air temperature method if the inside and outside temperature difference is at least 20 deg F, or use the difference between pitot tube traverses of the supply and return air ducts.
2. Static Pressure: Measure and record the static pressure at the inlet and outlet of each AHU component, including louvers, dampers, filters, coils, etc, and at each inlet and discharge duct connection.

D. Coils: Measure and record air and water flows and pressure drops.

E. Air Distribution Systems:

1. Zone, Branch and Main Ducts:

    a. Adjust to within 10% of design air flows. Balance so that at least one zone balancing damper is wide open. Balance multi-diffuser branch ducts so that at least one outlet or inlet damper is wide open.

2. Air Terminal Units:

    a. Calibrate flow sensors and enter design maximum and minimum flow setpoints into FMS.
    b. Record terminal unit number, size, specified flow, agency measured flow, FMS measured flow, and DDC flow correction factors.

3. Diffusers, Registers and Grilles:

    a. Test, adjust, and balance each diffuser, grille, and register to within 10% of specified design requirements. Record the size of each grille, diffuser, and register, initial flow measurement, and final measured flow.
    b. Where rooms are indicated to be maintained at either positive or negative pressure, balance air flows to achieve these conditions under design flow conditions, and verify proper pressurization at minimum flow.

F. Fan Coil Units, Unit Heaters, Cabinet Unit Heaters, Air Curtains, Door Fans, Fan Powered Terminal Units and other devices with fans and coils:

1. For each unit, record unit number, manufacturer, model, size, motor HP, voltage and rated load amps and design air flow.
2. Measure and record initial air flows, along with final air flows, unit inlet and outlet static pressures, voltages, and motor amps.
3. Measure and record initial and final water flows and pressure drops.

G. Energy Recovery Units:

1. For each unit, record unit number, manufacturer, model, size, motor HP, voltage and rated load amps and design air flow.
2. Measure and record initial air flows, along with final air flows, unit inlet and outlet static pressures, voltages, and motor amps.

H. Duct Leakage Testing

1. Specification Section 23 3000 describes the requirements for duct leakage testing. Provide all instrumentation and labor to take the required measurements.
2. The Mechanical Contractor shall provide the fans and all other required work.
3. Submit test report. Retest until ductwork complies with specified leakage criteria.

3.4 HYDRONIC SYSTEMS

A. General:

1. Prior to commencing hydronic balance:

    a. Set valves to proper position per the sequence of operation. Open all coil valves to full open position. Set 3-way valves to full flow through system component.
    b. Check pump rotation.
    c. Verify that system is adequately pressurized.

d. Set temperature controls so all system components deliver maximum flow.
e. Balancing may be done in sections.

2. Pumping Systems: Measure flows and determine operating characteristics of hydronic systems with pumps operating both independently and in parallel (where applicable). Make measurements at maximum flow.
3. Balance systems to minimize throttling out in the distribution, and to instead throttle at the pump discharge. Recommend impeller trimming if appropriate.
4. Measure and report performance readings on all pumps, coils, heat exchangers, heating and cooling water generating equipment, flow measurement devices, heat rejection equipment, etc. Measure and record the following for each item of hydronic equipment:

	Eqpt Type	Pumps (Note 1)	Chillers	Air Cooled Condensers	Cooling Towers	Hot Water Boilers	Steam Boilers	Heat Exchangers	Coils			
Tag No.		X	X	X	X	X	X	X	X			
Nameplate Data	Mfgr	X	X	X	X	X	X	X	X			
	Model	X	X	X	X	X	X	X	X			
	Serial	X	X	X	X	X	X	X	X			
	Volts	X	X	X	X	X	X					
	RPM	X	X	X	X	X	X					
	HP	X			X							
	FLA	X	X	X	X	X	X					
	Refrigerant		X	X								
Scheduled	GPM1	X	X		X	X		X	X			
	Press Drop	X	X		X	X		X	X			
	GPM2		X					X				
	Press Drop		X					X				
Measured	GPM1	X	X		X	X		X	X			
	Inlet Press	X	X		X	X		X	X			
	Outlet Press	X	X		X	X		X	X			
	Press Drop	X	X		X	X		X	X			
	GPM2	X	X					X				
	Inlet Press	X	X					X				
	Outlet Press	X	X					X				
	Press Drop	X	X					X				
	Volts	X	X	X	X	X	X					
	Amps	X	X	X	X	X	X					

Notes

1 For pumps measure pressure rise instead of pressure drop. Measurements for GPM2 shall be at shutoff conditions.

5. Domestic HW return system: Balance to ensure HW availability throughout the system. Where balancing valves are provided, record flow and balance to provide flow in each circuit.

3.5 LIMIT DEVICES AND SAFETY CONTROLS

A. Limit Devices: Check all limit devices to verify proper operation, including, freezestats, flow switches, etc. Include in the TAB report a list of all such devices and the results of their tests.

B. Fire and Smoke Dampers

1. Test each fire damper, smoke damper, and fire/smoke damper to ensure proper operation. Record test results.
2. Fire Dampers: Open access door, disconnect fusible link or activate thermal link, and verify that damper closes smoothly and completely. Reset damper and access door.
3. Smoke Dampers: Open access door, activate damper, observe whether it closes smoothly and completely, and measure closing time. Reset damper and verify it opens completely. Close access door and record test results.

C. Life Safety Controls: Test and record life safety control operation of the HVAC systems. Verify the installation of required smoke detectors in air handling equipment, and verify operation of the smoke detector by activating the smoke detector and observing air handler shutdown or other required functions as described on the control drawings and sequence of operation. With assistance from the contractors for mechanical, temperature controls and electrical work, verify the operation of interconnected systems, such as the smoke detector's activation of the fire alarm system and the alarm system's activation of the life safety control sequence.

3.6 SOUND TESTING

A. Measure sound level in approximately ten percent of rooms as directed by Engineer.

1. Shut off mechanical equipment and measure background sound level in each octave band.
2. Start mechanical equipment and measure sound level in each octave band.
3. Submit a plot of measured data against noise criteria (NC) curves.

B. Where measured sound levels are deemed by Owner to be unacceptable, work with Engineer and Mechanical Contractor to reduce actual levels, and retest as required.

3.7 AIR HANDLING SYSTEMS – SPECIAL APPLICATIONS

A. Rooms Requiring Air Flow Tracking and/or Active Room Pressure Control:

1. Calibrate flow sensors for all supply and exhaust air devices serving the room, and enter design maximum and minimum flow setpoints into FMS.
2. Calibrate room pressure sensor.
3. Verify proper air flow tracking and room pressure control as the system operates from maximum to minimum, and back to maximum flow.
4. Submit a separate sheet in the report for each such room. Include an air flow diagram showing each device in the air flow and control system, and record all pertinent design and measured data on this sheet, including but not limited to:

a. Air valves: Tag number, size, specified flow, agency measured flows and FMS measured flows at various flow conditions, and DDC flow correction factors.
b. Offset air flows and room pressures at various flow conditions.

B. Rooms to be Balanced to a Positive or Negative Pressure (Without the Use of Air Flow Tracking or Active Pressure Controls):

1. Balance supply and return air flows as required
2. Crack open the door and use a smoke puffer to demonstrate the direction of air flow. Test under maximum and minimum flows. Record test results.

C. Room Tightness Testing:

1. Where a room tightness test is specified, provide the instrumentation and labor to perform such test.
2. The Mechanical Contractor shall provide the fans and associated ductwork for the test.
3. Submit test report. Retest until room complies with room leakage criteria.

D. Fume Hoods and Biological Safety Cabinets: Test exhaust airflow by duct pitot tube traverse, and adjust exhaust air valve to control to within 5% of design flow. Balance makeup air flows as specified above. Test for turbulence and proper air flow patterns at the face and inside hoods using a smoke puffer or other approved smoke-emitting device. Document the test results, and advise of any concerns and recommendations.

E. Kitchen Hood Exhaust Systems

1. Air Flows: Test the exhaust air flow of each kitchen hood, and at each hood outlet connection. Use duct pitot tube traverses. Adjust fan speed as required to achieve design air flows. Adjust makeup air systems as required.
2. Capture Characteristics: For each Type 1 hood, set a smoke emitting device in several locations (minimum one location per four foot hood length, but not less than two locations per hood) and observe capture characteristics. Adjust makeup air system to optimize capture characteristics. Record test results.
3. Sealing test holes: After testing the Mechanical Contractor shall properly seal all test holes in the exhaust duct.

F. Building/Zone Pressurization: Test and adjust building/zone pressurization by setting the design flows to meet the required flow direction and pressure differential. For positive pressure areas, set the supply air to design flow, and gradually reduce the exhaust air rate to obtain the required flow or pressure difference. For negative pressure areas, set the supply air to design flow, and gradually increase the exhaust air rate to obtain the required flow or pressure difference.

G. Smoke Control Systems

1. General:

a. Test smoke control systems in the presence of the Owner's Representative and the Authority Having Jurisdiction (AHJ). Clearly document all test conditions. Record video of all tests, and include this recording in the final documentation.

b. Initial checkout: Activate the smoke control system to determine that the smoke detectors, fans, dampers, and other components function properly. Correct any problems encountered before proceeding with tests below.

2. Follow the requirements, recommendations, and guidelines of the AHJ. In the event that no such guidelines are available, do the following:

   a. Notify all appropriate agencies of the time, date, and location of the smoke removal test.
   b. Place smoke generating devices in required areas in preparation for the test.
   c. When all required parties are present, the smoke removal tests and shutdown will commence.
   d. Activate smoke generation equipment. (Superior Five-Minute Smoke Bomb, 100,000 cubic feet of smoke, or equivalent.)
   e. Observe smoke movement and record time required for exit signs to become clearly visible and time required to effectively clear space of smoke.
   f. Record the time it takes for the standby power system to restore power.
   g. Verify automatic activation by smoke detectors. Record data, time, etc.
   h. Videotape sequence until exit signs are clearly visible.

3. After the automatic test is completed as described above (test in which the smoke control system is activated by the fire alarm system), run a second test with manual activation at the Fire Command Station. Record time until exit signs are clearly visible again.

4. Stairwell Pressurization: Pressure shall not exceed 0.5" and shall be a minimum of .15" (test both stairs). Measure and record differential pressure from top at each level, all the way to the lowest level. Open two doors at mid-level and recheck pressure differential at top and lowest levels.

5. Confirm the following in writing prior to final testing:

   a. The building HVAC systems have been properly balanced and are in proper operation.
   b. A manual method of activating the smoke control system is installed in a location approved by the fire department.
   c. Smoke removal equipment functions with both normal and standby power.

6. Results: Record video indicating the duration of smoke test; delay time from smoke bomb ignition to activation of the smoke removal system; time when exit signs again become visible, and other data required by the AHJ.

END OF SECTION 23 0593

SECTION 23 0700 - MECHANICAL SYSTEMS INSULATION

PART 1 - GENERAL

1.1 REQUIREMENTS

A. Conform with applicable provisions of the General Conditions, Supplemental General Conditions and General Requirements.

1.2 RELATED SECTIONS

A. Section 23 0500, Common Work Requirements for HVAC.

B. Section 23 0504, Pipe and Pipe Fittings.

C. Section 23 3000, Air Tempering System and Equipment.

1.3 SCOPE

A. Field insulation of piping: see drawings and Part 3 of this specification.

B. Field insulation of ductwork: See drawings, Table 23 0700-1, and Part 3 of this specification.

C. Field insulation of equipment supplied and/or installed under Division 23: See drawings and Part 3 of this specification.

D. Factory-insulated equipment and materials are described on the equipment schedule, on the drawings, and in other sections of this specification.

1.4 SUBMITTALS

A. Submit products to be used including insulation, jackets, miscellaneous products, and products for special applications. Review each application and advise if any product is either not suitable for, or not recommended for the application.

B. Verify that each submitted product meets all requirements for that product as specified herein. Include literature that clearly shows products meet all aspects of the spec. Include a cover sheet or letter with the following statement:

> "Each product submitted here meets all specified requirements for that product except as follows:" followed by a list of any discrepancies.

C. Submit schedules showing the type of product and thickness for each application. Indicate products to be used on valves and fittings. Indicate where vapor barriers will be provided and what jackets will be used.

D. D-5, D-6 & D-7 insulation: If one of these insulations is specified, submit documentation indicating that the submitted materials are approved for the intended service.

E. Submit a description of the application techniques to be used.

1.5 QUALITY ASSURANCE

A. Comply with the latest edition of the National Commercial & Industrial Insulation Standards, as published by the Midwest Insulation Contractors Association.

B. Part 3 and Table 23 0700-1 give the system temperatures for various applications. Supplier shall review these temperatures and confirm the suitability of all components for the specified applications.

C. Test piping and ductwork in accordance with applicable specification sections before insulation is applied.

PART 2 - PRODUCTS

2.1 GENERAL

A. All materials must be 100% asbestos-free and 100% formaldehyde-free, NO EXCEPTION.

B. All materials must be GreenGuard Gold Certified.

C. Smoke and Fire Ratings: All materials shall have a composite fire and smoke hazard rating not exceeding flame spread 25, fuel contribution 50, smoke developed 50, when tested as assemblies per ASTM Standard E-84 or NFPA 255.

D. Thermal conductivities: Per ASTM C518. Do not exceed the conductivities indicated. Units listed herein for conductivity are Btuh-in/SF-F. Resistance shall not be less than the values specified herein. Units for resistance are SF-F/Btuh.

E. Noise Reduction Coefficients: Per ASTM C423 based on Type A mounting. NRC shall not be less than as specified.

F. Jackets: Maximum 0.02 perm water vapor transmission per ASTM E96 Procedure A.

1. ASJ: All service jacket per ASTM C1136 Type I, paintable white kraft paper outer surface reinforced with glass fiber yarn and bonded to aluminum foil, with self-sealing longitudinal lap and butt strips, breach puncture min. 50 oz-in/in tear per ASTM D781, tensile strength min. 30 lb/in per ASTM D828.
2. FSK: Foil skim kraft per ASTM C1136 Type II.

G. Fiberglass insulation: Inorganic fibers bonded with thermosetting resin.

H. Approved Manufacturers: Owens Corning, Johns Manville, Knauf, Certain-Teed, Kflex, Armacell, Unifrax -Insulfrax, Industrial Insulation Group, Pittsburgh Corning. Where the term

OAE is used herein, this refers to these manufacturers only. No other manufacturers are approved for this project.

2.2 PIPE INSULATION

A. General

1. Valves, Fittings, and Accessories: Use the same insulation materials and thickness as the pipe insulation, except as noted.

B. Type P-1, Fiberglass Pipe Insulation: Factory assembled insulation and ASJ. Pre-formed fiberglass per ASTM C547 Type I, suitable for use on surfaces from 0–850°F, with thermal conductivity 0.23 at 75°F or 0.33 at 250°F, and minimum 3 pcf density. ASJ shall have self-sealing lap at end and along length, with pressure sensitive tape lap sealing system. Owens Corning SSL II Pipe Insulation, Johns Manville Micro-Lok, Knauf Pipe Insulation.

1. Where Type P-1 insulation is used, insulate fittings, valves and accessories using one of the following:

a. Fiberglass pre-formed fitting insulation complying with the specification for P-1 pipe insulation, Johns Manville Hi-Lo Temp insulation inserts, Hamfab, OAE. Finish with Type J-2 fitting covers.
b. Where pre-formed fitting insulation is not available, the following may be used: minimum 0.75 pcf density fiberglass per spec for D-1 insulation except without FSK. Finish with Type J-2 fitting covers or with two coats of fitting mastic with fiberglass fitting tape embedded between coats.

C. Type P-2, Fiberglass Pipe and Tank Insulation: Similar to Type P-1 insulation and jacket, except with fibers oriented to allow insulation to be wrapped onto curved surfaces, with conductivity 0.30 at 100°F, or 0.55 at 400°F. Johns Manville Pipe & Tank Insulation, Owens Corning Pipe and Tank Insulation or Knauf Pipe and Tank Insulation.

1. Alternate: Fiberglass board insulation similar to Type D2, scored for application on curved surfaces, with ASJ.

D. Type P-3, Calcium Silicate Pipe Insulation: Rigid calcium silicate per ASTM C533, Type 1, asbestos-free, suitable for use on piping up to 1200°F, conductivity 0.55 at 700°F, compressive strength min. 200 psi at 5% compression. Industrial Insulation Group OAE.

1. Fittings, valves and accessories: Insulate with mitered Type P-3 insulation or Type D-7 insulation.

E. Type P-4, Elastomeric Foam Pipe Insulation: Pre-formed elastomeric foam, ASTM C534 Type 1 flexible, closed cell, suitable for use up to 220°F, UV protected, not to exceed flame spread 25 and smoke developed 50 based on 0.75-inch thickness, conductivity 0.30 at 75°F. Kflex, Armacell OAE.

1. Fittings, valves and accessories: Insulate using either Type P-4 insulation pre-formed for use on fittings and valves, or cut sections of P-4 pipe insulation to match the shape of the fitting or valve, taped on using PVC tape.

2.3 DUCTWORK INSULATION

A. Type D-1, Fiberglass Blanket: Factory fabricated insulation and FSK jacket assembly suitable for applications from 40-250ºF, 3/4 pcf fiberglass, ASTM C553 Type I or II, with thermal resistance not less than the following for 2-inch thickness: 6.8 out of the box, 5.6 installed with 25% compression. Johns Manville Microlite XG Duct Wrap, Owens Corning Soft R Duct Wrap, Knauf Friendly Feel Duct Wrap, Certainteed Soft Touch Duct Wrap.

B. Type D-2, Fiberglass Board: Similar to Type D-1 except rigid board type, 3 pcf density, thermal conductivity 0.23 at 75ºF, NRC 1.36, suitable for unfaced side at up to 450ºF and faced side at up to 150ºF. Johns Manville 800 Series Spin Glas, Owens Corning 700 Series Board, Knauf Insulation Board, Certainteed Certra Pro Commercial Board

C. Type D-3, Acoustic Lining (roll type): Organic fiber or fiberglass duct liner bonded with thermosetting resin, with factory-applied acrylic surface coating treated with anti-microbial agent, and factory-applied or shop-applied edge coating.

1. Properties: Minimum 1.5 pcf density, thermal conductivity 0.24, 6000 FPM rated per UL 181, NRC 0.70 at 1-inch thick and .95 at 2-inch thick. The product (fiberglass, resin, coating, microbial agent and adhesive) as an assembly shall be suitable for surfaces and gases up to 250ºF, and shall comply with ASTM C1071 (Type I), G21 and G22.
2. Lining surface shall be cleanable using commercially available duct cleaning equipment when performed by qualified technicians using procedures established and recommended by the North American Insulation Manufacturer's Association (NAIMA) Duct Cleaning Guide.
3. Johns Manville Linacoustic RC, Owens Corning Acoustic R duct liner, Knauf EM duct liner, Certainteed ToughGuard R Duct Liner.

D. Type D-4, Acoustic Lining (board type): Similar to Type D-3 and complying with all aspects of the spec for Type D-3 insulation, except 3 pcf density rigid board with NRC 0.75 at 1-inch thick and 1.0 at 2-inch thick. Johns Manville Permacote Linacoustic R-300. Owens Corning Duct Liner Board, Knauf Rigid Plenum Liner, Certainteed Rigid Liner Board.

E. Type D-5, Grease Duct Applications: High temperature, foil-encapsulated inorganic blanket, 8 pcf. Insulfrax Fyre Wrap Max 2.0, Johns Manville Fire Temp, OAE. Product shall meet the following when applied as 2-layers around a grease-duct:

1. Tested and listed for zero clearance to combustibles across the entire surface of the blanket material per internal fire test AC101 or ASTM E2336 - Internal Fire Test – 2 Hr Grease Duct Enclosures.
2. Rated as a 2-hr fire resistive enclosure assembly per ASTM E-119, Engulfment Fire Test for 2-hr Grease Duct Enclosure.

F. Type D-6 –Combustible Materials within Plenum: For use on combustible materials located within supply or return air plenums, foil-encapsulated 8 pcf high-temperature ceramic fiber blanket suitable for service up to 1800ºF. Unifrax Fyre-Wrap 0.5 plenum insulation.

G. Type D-7 – Fire Rated Ductwork: Suitable for continuous operation at 1800ºF, 6-pcf, foil-encapsulated inorganic blanket to provide a 2-hour rating per ISO 6944 when applied in a single

1.5-inch thick layer. Insulfrax FyreWrap 1.5 OAE.

H. Type D-8 – Polystyrene Insulation: Rigid cellular square edge insulation per ASTM C578, waterproof, thermal conductivity 0.20, compressive strength 25 psi. Dow Styrofoam or Owens Corning Foamular.

I. Type D-9 – Fiberglass Ductboard: Listed per UL 181 as a Class 1 Rigid Air Duct; conforming to ASHRAE Std. 62, NFPA-90A and 90B, ASTM G-21 & G-22; rated for 2-in. wg; constructed of fiberglass bonded with a thermosetting resin, with double density slip joints pre-molded in the board; FSK jacket; thermosetting acrylic polymer interior surface, and black interior surface color. Thermal conductivity 0.23, and NRC 0.70 at 1-inch thick and 1.0 at 2-inch thick. Johns Manville Superduct 475 or 800, Owens Corning Quiet R Duct Board, Knauf Duct Board M, Certainteed ToughGard Duct Board

2.4 EQUIPMENT INSULATION

A. E-1, Removable Insulating Blanket: Factory fabricated, one-piece, removable and re-usable insulating blanket with fiberglass insulation completely enclosed within a silicone coated fiberglass cloth with draw cords of SS or PTFE coated glass fiber, and stainless steel clips. Insulation thickness shall be as specified elsewhere, but not less than 1-inch. Energy Systems Inc. “Q-Master” OAE.

2.5 INSULATION JACKETS

A. Type J-1, Metal Jacket: 0.010-inch smooth Type 304 stainless steel or 0.016-inch smooth or embossed aluminum per ASTM B-209, with minimum 1-mil polyethylene film with protective layer of 40 Lb virgin kraft paper, continuously laminated to full width inside jacket. Childers OAE.

1. Where jacket diameter is 16–96 in: 0.016-in. SS or 0.020 in. aluminum.
2. Equipment heads and all surfaces where jacket is greater than 96-inch OD: 0.020-inch SS or 0.024 inch aluminum.
3. Fittings and Accessories: Provide the same jacket material as for pipe.

B. Type J-2, PVC Jacket: Minimum 20 mil sheets and 30-mil pre-molded fitting covers, ASTM D1784, Class 16354-C. Accessories include solvent weld solution, stainless steel tacks, and tape. All components shall be white, UV resistant, with paintable exterior surface, and suitable for use at –20 to +150ºF. Johns Manville System 2000 (sheets), Zeston 300 (fitting covers), and Perma-Weld (solvent cement), OAE.

C. Type J-3, Canvas Jacket: 10 x 10 fiberglass mesh.

2.6 MISCELLANEOUS PRODUCTS

A. General:

1. Tapes: Aluminum, pressure sensitive, UL 181A-P listed and embossed, minimum 2.5-inch wide, Nashua 324A OAE.

2. Duct Liner Adhesives: Water-based, complying with ASTM C916.
3. Solvent Cement for PVC Jackets: Johns Manville Perma-Weld OAE.
4. Staples: Outward clinching, 0.5-inch galvanized steel

B. Piping Systems:

1. Pipe Hanger Insulation Inserts: Mechanical Pipe Shields Inc. “Snapp Itz” OAE.

C. Ductwork Systems:

1. Duct Liner Edge Sealer, Surface Sealer, Coatings & Adhesives: To meet ASTM C916. Johns Manville Superseal OAE.

2.7 SPECIAL APPLICATIONS

A. Handicap Lavatory Insulation Kit: Handi-Lav-Guard insulation kit per ANSI A117.1 with flexible vinyl finish.

PART 3 - EXECUTION

3.1 GENERAL

A. Delivery, Storage and Handling: Deliver and store insulation materials in factory-supplied containers. Protect from moisture. Do not install any materials that have gotten wet, regardless whether they are subsequently dried.

B. Store and apply materials in accordance with manufacturers’ recommendations, but not less than the following minimum temperatures. Ensure surfaces are clean and dry prior to application, and for minimum two hours after application:

1. Sealers, coatings, solvents and adhesives: 40^{o}F.
2. Tapes 50^{o}F.

C. Install in accordance with manufacturer’s recommendations, NAIMA recommendations, and this spec. Provide good ventilation.

D. Where vapor barriers are specified, ensure that the entire system is vapor sealed.

E. Protect materials from water damage. Replace any materials that are water-damaged prior to substantial completion.

3.2 PIPING INSULATION

A. General: Insulate piping as indicated herein and/or on the drawings. Except as noted, insulate all valves, fittings, and accessories with the same material and thickness specified for the pipe. Where piping is specified with a separate insulation jacket provide this same jacket for valves, fittings and accessories. Vapor seal cold piping systems.

1. Where insulation terminates, provide insulating cement beveled for a neat finish. For vaporsealed piping, coat with insulating mastic prior to applying insulating cement.
2. Strainers and Suction Diffusers: Either Type P-1 or P-3 insulation. Make provisions to easily remove and re-install insulation.
3. Pipe Supports: Provide high density calcium silicate insulation or insulation inserts as specified. Maintain pipe jacket and vapor barrier at supports. If necessary, apply a heavy coating of vapor barrier mastic material to prevent condensation from forming on supports. Provide galvanized steel insulation shields to protect insulation and jackets at supports.
4. Penetrations Through Building Construction: Insulation shall be continuous where piping passes through walls, floors, and other construction. Where insulated piping passes through fire and/or smoke rated construction, provide a section of UL approved fire safing insulation to match the required insulation thickness, or provide an insulated pipe sleeve as manufactured by Pipe Shield, Inc., OAE.
5. Mechanical Couplings: Where mechanical couplings are permitted, insulate them as specified for fittings.
6. Steam Traps: Do not insulate.
7. Retrofit Projects: Match the thickness of existing insulation where new insulation adjoins existing. Integrate new vapor barrier with existing so the insulation barrier is continuous for both new and existing piping.
8. All voids formed by support saddles or other mounting or support hardware shall be filled with insulation.

B. Application:

Temp Range	Temp (F)	Insulation Type	Vapor Sealed	Pipe Size				
				Under 1	1 - 1.5	Over 2 - 3	4 & 6	8 & Larger
TR-1	60&Less	P-1 or P-4	Yes	1.5	1.5	1.5	1.5	1.5
TR-2	61 – 104	P-1	Yes	0.5	0.5	0.5	0.5	0.5
TR-3	105 - 140	P-1	No	1.0	1.0	1.0	1.0	1.0
TR-4	141 - 200	P-1	No	1.5	1.5	2.0	2.0	2.0
TR-5	201 - 250	P-1	No	1.5	1.5	3.0	3.0	3.0
TR-6	251 - 350	P-1	No	1.5	2.5	3.0	3.0	3.0
TR-7	Over 350	P-1	No	2.5	3.0	3.0	4.0	4.0

1. Temperature Range TR-1: Refrigerant suction, condenser water (outdoor piping subject to freezing).
2. Temperature Range TR-2: Domestic cold water, makeup water, soft water, industrial water, process water of any type, non-potable water, HVAC make-up water (except insulation is not required for evap cooler makeup piping outdoors), interior horizontal roof drain and overflow bowls and piping, condensate drains indoors.
3. Temperature Range TR-3: Domestic hot water (including non-circulating HW within interior walls and chases) and domestic HW return except as noted.
4. Temperature Range TR-4: Heating water supply and return, low pressure steam condensate, pumped condensate return, engine cooling water.

C. Special Applications

1. Handicap Lavatories: Insulate domestic hot and cold water piping and P-traps exposed below handicapped lavatories with insulation kit specifically designed for the application.
2. Heat Traced Piping: Oversize insulation as required to accommodate heat tracing. Provide metal jacket.
3. Plastic pipe in return air plenums: Provide 0.5-inch type D6 insulation.
4. Piping subject to freezing and heat traced piping: Insulate all such piping (including drain piping) with thicknesses specified, but not less than 1.5-inch thickness. Oversize insulation to accommodate heat tracing where indicated. Provide J1 jacket.

D. Type P-1 & P-2, Fiberglass Insulation: Install in accordance with manufacturer's recommendations.

E. Type P-3, Calcium Silicate Insulation: Adhere to pipe or equipment using stainless steel wire. Provide removable J-1 jacket.

F. Type P-4, Elastomeric Foam: Seal all butt ends and longitudinal joints with Halstead Adhesive. When exposed to the weather, protect flexible tubing insulation with two coats of exterior weatherproof coating as recommended by manufacturer.

G. Jacketing: In addition to the finish and jacket specified for the particular type of insulation, provide the following:

1.	Indoor piping exposed to physical damage	Type J-2, PVC
2.	Mechanical Eqpt Spaces: Exposed piping less than 8 ft above floor or operator platform	Type J-2, PVC
3.	Exterior piping	Type J-1, Metal

3.3 DUCTWORK INSULATION

A. General:

1. Insulate all ducts except those specified to be uninsulated. The following ductwork need not be field insulated:

    a. Factory insulated ductwork and plenums.
    b. Ducts with acoustic lining, provided the lining thickness matches or exceeds the required insulation thickness.
    c. Exhaust ducts, except where noted.
    d. Return air ducts, except where noted.

2. See Table 23 0700-1 for additional information.
3. Ensure that ductwork is leakage tested prior to applying insulation. Inspect ductwork and repair any deficiencies prior to applying insulation. Do not apply insulation over deficient ductwork or plenum construction.
4. Ensure that ductwork is clean and dry before applying insulation.
5. For ductwork with acoustic lining the drawings indicate the "clear inside duct dimension" required. Over-size ducts as required to provide the required air flow area.

B. Type D-1, Fiberglass Blanket Insulation: Measure and cut insulation. Install so insulation is not excessively compressed at corners. For rectangular and flat oval ducts 24-inches and wider,

provide stick pins and speed clip washers 18-inches on centers on the bottom, and clip off excess length of stick. Firmly butt insulation ends and longitudinal joints. Overlap jacket minimum 2-inches at end joints and longitudinal joints, staple on 6-inch centers, and continuously seal jacket. Provide vapor barrier mastic where ducts are indicated to be vaporsealed. Should gaps or fishmouths occur, re-staple and seal them with mastic. Use FSK tape and vapor barrier mastic to seal all penetrations of the FSK jacket, such as pins, tears, and hangers. Neatly trim and seal insulation at access doors, ends, damper rod controls etc. Verify proper damper operation.

C. Type D-2, Fiberglass Board Insulation: Attach with mechanical fasteners 12" on centers.

D. Type D-3 & D4, Acoustic Lining: Ductwork dimensions indicated on the drawings are net air flow dimensions inside liner. Increase duct size to accommodate liner. Completely line the inside surfaces of ducts and plenums specified and indicted. Comply with the NAIMA Fibrous Glass Duct Liner Standard (FGDLS), manufacturer's recommendations, and this spec. Adhere liner with minimum 90% coverage of adhesive, and secure with mechanical fasteners and washers per FGDLS and manufacturer's recommendations. Fastener length shall be sufficient to limit compression of liner to 1/8" maximum. Coat all cut edges and surface penetrations with edge sealer. Provide metal nosing for liner leading edges at fan discharge and for all ducts with air velocities exceeding 3,000 FPM. Maintain minimum 18-inch clearance from electric resistance heaters. Interrupt liner at dampers and apply external insulation at these locations.

1. Provide Type D-3 insulation for the 10 feet upstream of roof exhaust fans except in wet air streams.

E. Type D-5: Install insulation in a 2-layer system per manufacturer's instructions, including the use of mechanical fasteners for the underside of ducts, butting or overlapping of joints, and offsetting of joints on outer layer.

F. Type D-6: Install in accordance with manufacturer's instructions. Overlap seams and joints minimum 2-inches, affix with SS wire minimum 18-inches on centers, but not less than per manufacturer's recommendations, and tape seams and joints with aluminum tape.

G. Type D-7: Install insulation in a single-layer system per manufacturer's instructions. Mechanical fasteners for the underside of ducts shall be adhered to the duct in a manner suitable for the operating temperatures (welded or other suitable method). Butt or overlap joints per manufacturer's recommendations.

H. Type D-8: Wire in place with SS wire minimum 12-inches on centers, and provide J-1 jacket.

I. Type D-9: Install per manufacturer's recommendations, NAIMA standards, and SMACNA Fibrous Glass Duct Construction Standards. Provide ship lap seams and joints.

3.4 EQUIPMENT INSULATION

A. General: Where specified elsewhere, equipment will be factory insulated. Insulate all equipment as noted herein except portions of equipment that are factory insulated.

1. Fiberglass Board Insulation: Score, bevel, or miter to provide tight joints and secure in place with mechanical pin and clip fasteners and insulation bonding adhesive applied to

underside surfaces, or with bands. Fill joints with insulation material and provide corner beads to protect edges of insulation.

2. Cold Tanks and Equipment: J3 jacket with two coats of approved vapor barrier mastic.
3. Factory Packaged Equipment: Field insulate the equipment and piping on factory-fabricated assemblies as if they were field installed, unless such items are factory insulated.

B. Storage Tanks: 2-inch type P2.

3.5 JACKETING

A. Type J-1, Metal Jacketing:

1. Ducts: Slope jacketing to shed rain.
2. Pipes: Install with seams at the 3 o'clock or 9 o'clock position to shed water. Band 12" on centers.
3. Joints and Seams: Overlap joints minimum 2-inches. Caulk with a weatherproof caulk when located outdoors.

B. Type J-2, PVC Jacketing: Secure in place with tacks and solvent welded joints. White PVC tape may be used indoors.

C. Type J-3, Canvas Jacket: Apply mastic at a rate of 60 to 70 sq. ft. per gallon, embed fiberglass mesh, smooth all wrinkles and apply finish coat of Sealfas, or equivalent.

END OF SECTION 23 0700

TABLE 23 0700-1 – DUCTWORK INSULATION

Service	Location	Condition	Insulation Type	Insulation Thickness (in)	Notes
Supply Air, Makeup Air, Outside Air	Indoor	Concealed	D1	1.5	1, 6
Supply Air, Makeup Air, Outside Air	Indoor	Exposed	D2	1.5	
Supply Air, Makeup Air, Return Air	Outdoor	All	D8	2	2, 4, 7
Supply Rectangular Ductwork downstream of Terminal Units, Fan Coil Units, Blower Coils and Low Velocity AHU's	Indoor	All	D1	1.5	1, 3
Return Rectangular Ductwork upstream of Fan Coil Units, Blower Coils and Low Velocity AHU's	All	All	D1	1.5	1, 3
Ductwork indicated to be lined	All	All	D3	1	5
Ductwork indicated to be lined with 2-inch acoustic lining	All	All	D3 or D4	2	5
Single Wall Lined Plenums	All	All	D4	2	
Transfer Air Ducts	All	All	D3 or D9	1	
Exhaust Ductwork	Indoor	Concealed	D1	1.5	8
Exhaust Ductwork	Indoor	Exposed	D2	1.5	8
Kitchen Exhaust Ductwork	Indoor	All	D5	2-layers	
Plastic Piping and Ductwork within RA Plenums	Indoor	Concealed	D6	0.5	
Fire-Rated Ductwork Other than Kitchen Exh	Indoor	All	D7	1.5	
Boiler Breeching & Stack	Indoor	All	P1 or P2	3	
Boiler Breeching & Stack	Outdoor	Exposed	P1 or P2	3	4, 7

Notes:

1 Includes Supply Air Duct from Energy Recovery Units and Evaporative Coolers.
2 Provide acoustical liner as indicated on the drawings.
3 Delete Type D1 insulation if acoustical liner is indicated by plan notes or shown on the drawings.
4 Provide J1 Jacket.
5 In hospitals do not provide acoustical lining in supply ductwork or plenums downstream of the final filter.
6 Vaporseal ducts conveying cold air.
7 Seal outdoor ductwork to prevent ingress of moisture.
8 Insulate only the portion of exhaust ductwork between isolation damper and outside.

SECTION 23 0800 - MECHANICAL FACILITY STARTUP/COMMISSIONING FOR HVAC

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope Of The Work

1. The purpose of this section is to specify Division 23 responsibilities and participation in the commissioning process. The owner will hire the Commissioning Authority for the project.
2. The Owner will hire the HVAC test and balance firm as denoted in Section 23 0593. The Commissioning Authority will coordinate the activities of the HVAC test and balance firm.
3. The Contractor is responsible to provide support required for start-up, testing, and commissioning. The commissioning process requires significant participation of Division 23 to ensure all portions of the work have been completed in a satisfactory and fully operational manner.

B. Minimum requirements for Contractor:

1. Start-up and testing of the equipment supplied.
2. Operate and maintain equipment and systems as required for commissioning tests.
3. Providing qualified personnel including equipment manufacturer's service technicians for participation with the commissioning team.
4. Provide equipment, materials, and labor necessary to correct deficiencies found during the commissioning process, which fulfill contract and warranty requirements.
5. Provide operation and maintenance information and record drawings for verification, organization, and distribution.
6. Provide assistance to the Commissioning Authority (CA) to develop and edit equipment startup and testing schedules (Commissioning Matrix).
7. Provide training for the systems specified in this division with coordination by the Contract Administrator and Commissioning Authority.
8. Attend commissioning meetings.

1.2 RELATED WORK

A. All start-up and testing procedures and documentation requirements specified within Division 23.

B. Allow sufficient time before final commissioning dates so that testing, adjusting and balancing can be accomplished.

C. Put all heating, ventilating, and air conditioning equipment and systems into full operation and continue the operation during each working day of testing, adjusting and balancing and commissioning.

D. Provide labor and material to make corrections when required.

1.3 DEFINITIONS

A. Point Verification Forms (PVF) are detailed installation and startup tracking documents developed by the Commissioning Authority and completed through a cooperative effort between the Contractor and the Commissioning Authority. The PVFs will track each point through installation, termination, and connection to the Facility Management System (FMS).

B. Functional Performance Tests (FPT) are detailed testing procedure developed by the Commissioning Authority, and conducted through a cooperative effort between the Contractor and the Commissioning Authority. The FPTs will be detailed step by step procedures developed for each HVAC system. Each FPT will have a clear acceptance criteria based in the contract documents which must be achieved before the system or sub-system is accepted by the Commissioning Authority and the Owner.

C. The Commissioning Authority (CA) is a firm hired directly by the Owner to oversee the entire commissioning process.

PART 2 - PRODUCTS

Not Applicable.

PART 3 - EXECUTION

3.1 WORK PRIOR TO COMMISSIONING

A. Complete all phases of work so the system can be started, tested, adjusted, balanced, and otherwise commissioned. Division 23 has primary start-up responsibilities with obligations to complete systems, including all sub-systems so they are fully functional and ready for startup and testing. This includes the complete installation of all equipment, materials, pipe, duct, wire, insulation, controls, etc., per the contract documents and related directives, clarifications, change orders, etc.

B. A commissioning plan will be developed by the CA and approved by the commissioning team. Division 23 is obligated to assist the CA in preparing the commissioning plan by providing all necessary information pertaining to the actual equipment and installation. If system modifications/clarifications are in the contractual requirements of this and related sections of work, they will be made at no additional cost to the Owner. If Contractor initiated system changes have been made that alters the commissioning process, notify the Commissioning Authority and Contract Administrator for approval.

C. Specific pre-commissioning responsibilities of Division 23 are as follows:

1. Bring each system into a fully operational state. This includes cleaning, filling, purging, leak testing, motor rotation check, control sequences of operation, full and part load performance, etc as required. The TAB firm will not begin the TAB work until each system is complete, including normal contractor start-up. The CA will not initiate FPTs

until each system is complete, including normal contractor start-up and the TAB work has been completed.

2. Commissioning is intended to begin upon completion of a system. Commissioning may proceed prior to the completion of systems, or sub-systems, and will be coordinated with the CA. Start of commissioning before system completion will not relieve Division 23 from completing those systems as per the schedule.

3.2 PARTICIPATION IN COMMISSIONING

A. Provide skilled technicians to start up all systems within Division 23. These same technicians shall be made available to assist the CA in completing the commissioning program as it relates to each system and their technical specialty. Work schedules, time required for testing, etc., will be requested, coordinated by the CA, and tracked on the Commissioning Matrix. Division 23 will ensure that the qualified technician(s) are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustment, and/or problem resolutions.

B. System problems and discrepancies may require additional technician time or reconstruction of systems and system components. The additional technician time shall be made available for the subsequent commissioning periods until the required system performance is obtained.

C. The Contract Administrator and CA reserve the right to judge the appropriateness and qualifications of the technicians relative to each item of equipment or system. Qualifications of technicians include expert knowledge relative to the specific equipment involved, adequate documentation and tools to service/commission the equipment, and an attitude/willingness to work with the commissioning team to complete the job.

3.3 WORK TO RESOLVE DEFICIENCIES

A. In some systems, misadjustment, misapplied equipment and/or deficient performance under varying loads will result in additional work being required to commission the systems. This work will be completed under the direction of the Contract Administrator, with input from the Contractor, equipment supplier, and CA. Whereas all members will have input and the opportunity to discuss the work and resolve problems, the Contract Administrator will have final jurisdiction on the necessary work to be done to achieve performance.

B. Corrective work shall be completed in a timely fashion to permit completion of the commissioning process according to the schedule. Experimentation to render system performance will be permitted. If the CA deems the experimentation work to be ineffective or untimely as it relates to the commissioning process, the CA will notify the Owner indicating the nature of the problem, expected steps to be taken, and the deadline for completion of activities. If deadlines pass without resolution of the problem, the Owner reserves the right to obtain supplementary services and/or equipment to resolve the problem. Costs incurred to solve the problems in an expeditious manner will be the Contractor's responsibility.

3.4 TRAINING

A. Participate in the training of the Owner's engineering and maintenance staff, as required in

Divisions 23, on each system and related components. Training, in part, will be conducted in a classroom setting, with system and component documentation, and suitable classroom training aids.

B. Training will be conducted by the Contractor and the equipment vendors.

C. Training for the Commissioning Team members on the Commissioning Plan will be provided by the CA. All Commissioning Team members are required to attend this training.

3.5 SYSTEMS DOCUMENTATION

A. In addition to the requirements of Division 23, update contract documents to incorporate field changes and revisions to system designs to account for actual constructed configurations. Red-line all drawings on two sets. Include architectural floor plans, elevations and details, and the individual mechanical or electrical systems in relation to actual building layout in Division 23 as-built drawings.

B. Maintain as-built red-lines as required by Division 1. Given the size and complexity of this project, red-line drawings at completion of construction, based on memory of key personnel, is not satisfactory. Continuous and regular red-lining of drawings is considered essential and mandatory. Maintain these drawings in the construction trailer and make them available for inspection at any time.

3.6 MISCELLANEOUS SUPPORT

A. Division 23 shall remove and replace covers of mechanical equipment, open access panels, etc., to permit Contractor, Contract Administrator, or CA to observe equipment and controllers provided.

END OF SECTION 23 0800

SECTION 23 0900 - FACILITY MANAGEMENT SYSTEM

PART 1 - GENERAL

1.1 REQUIREMENTS

A. The entire Facility Management System (FMS) specified hereafter shall be approved and listed by Underwriters' Laboratories, Inc., under UL 916 (Standard for Open Energy Management
B. Equipment).

1.2 RELATED SECTIONS

A. Section 23 0500, Common Work Requirements for HVAC.

B. Section 23 0505, Piping Specialties.

C. Section 23 0523, Valves.

D. Section 23 0549, HVAC and Electrical Installation Coordination.

E. Section 23 0550, Variable Frequency Drives.

F. Section 23 0593, Testing, Adjusting and Balancing.

G. Section 23 0800, Commissioning.

1.3 SCOPE

A. It is the intent of this Section to provide, install, connect, and calibrate the entire Facility Management System (FMS) as indicated on the Drawings and as necessary to provide fully automatic control for all systems as shown in the control drawings, stated in the sequences of operation, indicated in the electrical ladder diagrams, or as otherwise indicated in the Contract Documents. Some equipment controls may be specified to be provided in the Contract Documents outside this Section. As work of this Section, the Contractor shall coordinate with these other suppliers and trades to provide a completely integrated control system.

B. It is the responsibility of the bidder to read and conform to all sections of the Specifications, review all Contract Drawings of all Divisions, and coordinate with all equipment suppliers of material specified under other sections of the Specifications including any Owner-furnished equipment.

1. The engineering, installation supervision, programming, graphics development, calibration, startup, and checkout necessary for a complete and fully operational control system as specified hereafter shall be provided under this Section.

C. Provide startup documentation verifying proper operation of all points and all integrated systems.

D. Provide integration of packaged air handling units, VFD's, and boilers into the FMS as outlined on the drawings, in the sequence of operations, or in the specifications.

E. Provide training and instruction of the installed control system.

1.4 APPROVED MANUFACTURERS

A. Facility Management System suppliers will be authorized factory representatives or branch offices of Alerton Technologies, Trane, or Automated Logic. Manufacturers not listed will be required to submit a prior approval request verifying compliance with this Section of the Specification and be approved in accordance with the Contract Documents by the owner.

1.5 SUBMITTALS

A. Within thirty (30) days of contract award, submit eight (8**)** sets of shop drawings and submittal data in accordance with Section 23 0500 and the General Contract Requirements. These submittals shall be delivered first to the mechanical and electrical sub-contractors for coordination review and evaluation prior to being submitted for final review. Letters from these sub-contractors verifying that they have reviewed the submittals, and any comments regarding the submittals, must be attached as part of the final submittal.

B. Submittals shall consist of shop drawings, catalog data sheets, and point verification forms as defined in the following paragraphs.

1. Shop drawings shall be provided which show all control devices, electrical ladder diagrams, control system schematics, sequences of operation, and a material list. All systems and the associated control components, as well as all connections between components, shall be clearly indicated. The submittal shall clearly indicate the required coordination with equipment supplied by others, including any Owner-furnished equipment. Simply showing a connection with no identification or termination will be considered unacceptable. All connections shown on the Drawings shall be labeled on both ends and these same labels shall be used for the installation process for ease of comparing the shop drawings to the actual field installation. Each control component shall be given a unique identifier. This identifier shall be used in the sequence of operation so that reference to the Drawings can be easily made. A complete FMS communication and power architecture drawing shall also be included on the shop drawing.

    a. Electrical ladder diagrams shall be shown on the shop drawings. Electrical ladder diagrams shall show all switches, relays, motor starters, etc. The electrical ladder diagrams shall show the correct control wiring and interlock wiring of all equipment provided under the Contract including any Owner-furnished equipment. Each diagram shall reference the correct power source by breaker panel and circuit number or from a control transformer. If equipment shown is provided by another Contractor, then this shall be noted.
    b. The sequence of operation for each controlled system shall be provided with

reference to the control device identifier. The sequence of operation shall break down the control operation by major function (i.e., mixed air control, occupied-unoccupied, smoke purge, etc.,) and describe in detail the correct operation and interaction with other system functions. Use of the sequence of operation stated on the Drawings is acceptable; however, it shall be modified to reflect actual control device identifiers.

c. A complete material listing shall be included on the shop drawings which show the device model numbers, device identifiers, quantities, manufacturers, etc., of all equipment provided under this Section. The material list shall be organized in alphabetical order so that it can be easily compared to the associated catalog data sheets. The quantities are to be provided only to confirm a general understanding of the contract requirements and will not be verified as a complete material list.

2. Catalog data sheets will be provided for each different piece of equipment provided under this Section. At a minimum the data sheet shall contain sufficient information so that compliance with the Specification can be verified. Where multiple models or options are indicated on the same catalog data sheet, the equipment proposed shall be highlighted or otherwise indicated. The catalog data sheets shall be organized in alphabetical order to match the material listing on the shop drawings.
3. An integration plan shall be provided for each system being integrated into the FMS. The plan shall contain all systems, points, descriptions, addresses, and default values to be integrated. The contractor shall work with the system providers to compile this information prior to connection of the system to the FMS. This plan shall be submitted and approved by the Owner/Engineer before integration occurs.
4. Point verification forms shall be completed for all points that will be installed as part of the FMS. Once approved, these forms shall be used during the testing and startup portions of this work. A template point verification form is located at the end of this Section.
5. All Graphic Slides (or typical graphics for identical equipment) proposed for use on this Project shall be submitted for review and approval. The submitted slides shall be printed in color. All realtime display fields, user input fields, etc., shall be clearly indicated. No graphic software shall be installed on the job site until the Graphic Slides have been approved.
6. Software Development parameters including all trend logs, reports, point alarm parameters, passwords, and scheduling shall be submitted based on the contents of this Specification Section. The information contained in this portion of the submittal will be followed during development of the programming code and shall be used for evaluation of the system's performance during the commissioning phase.

    a. Report templates shall indicate what information will be presented on each report, how the information will be presented, report hard disk upload parameters, and report log file names.
    b. If user authentication is required in any part of the installed system blank forms shall be submitted for completion of user information by the Owner. The forms shall allow the Owner to fill in the operator's name and approved password level. During Owner training, the FMS programmers shall coordinate with the approved operators to allow the operators to input their private passwords.
    c. Blank schedule forms for each air handling system shall be submitted for completion by the Owner. Additionally, a blank schedule group form template shall be submitted so the Owner can identify schedule groups of HVAC equipment.

7. The names, phone numbers, e-mail addresses, job descriptions, pager numbers, mobile phone numbers, etc., shall be provided for the project manager, project engineer, project programmer(s), installation foreman, and any other individuals key to the completion of this project. If at any time during the project the assignment of personnel changes, the Owner and the Engineer shall be notified and the previously listed information shall be furnished for the newly assigned individuals.

C. All re-submittals shall contain a cover letter restating all of the previous submittal comments made by the reviewing engineer along with a written statement by the Contractor as to the resolution of each item. Any re-submittal issued to the engineer without this cover letter will result in an automatic rejection of the submittal.

1.6 RECORD DRAWINGS

A. Record drawings shall be provided as required by Section 23 0500 and the General Contract Requirements. Record drawings shall not be completed until after installation is complete. Any changes made during installation shall be recorded on the approved shop drawings as they are made so that a current record drawing is constantly being updated. These as-constructed drawings shall be available at all time for inspection by the Owner's Representative. At completion of the project, all manual changes shall be incorporated into a clean reproducible set of as constructed drawings. These as-constructed drawings shall be available for use during the training sessions.

B. With the reproducible record drawings the Contractor shall furnish a complete spare parts lists, operating instructions, and maintenance literature, for proper maintenance of all control equipment, in accordance with the requirement specified in Section 23 0500.

C. In addition to the record drawings, the following documents and manuals will be delivered to the Owner. Two (2) sets of these documents will be provided prior to training begins:

1. Names, address and 24-hour telephone numbers of Contractors installing equipment, and the control systems and service representative of each.
2. Operators Manual with procedures of operating the control systems including logging on/off, alarm handling, producing point reports, trending data, overriding computer control, and changing set points and other variables.
3. Programming Manual with a description of the programming language including syntax, statement descriptions including algorithms and calculations used, point database creation and modification, program creation and modification, and use of the editor.
4. Engineering, Installation and Maintenance Manual(s) that explains how to design and install new points, panels, and other hardware; preventative maintenance and calibration procedures; how to debug hardware problems; and how to repair or replace hardware.
5. A listing and documentation of all custom software created using the programming language including the point database. One set of magnetic media containing files of the software and database shall also be provided.
6. One set of electronic media containing files of all color-graphic screens created for the project.
7. Complete original issue documentation, installation, and maintenance information for all third party hardware provided including computer equipment and sensors.
8. Complete original issue media for all software provided including operating systems,

programming language, operator workstation software, and graphics software.

9. Licenses and warranty documents for all equipment and systems.
10. Recommended preventive maintenance procedures for all system components including a schedule of tasks, time between tasks, and task descriptions.

D. Training Materials: The Contractor shall provide a course outline and training material for all training classes at least six weeks prior to the first class. The Owner reserves the right to modify any or all of the training course outline and training materials. Review and approval by Owner and Engineer shall be completed at least 3 weeks prior to first class.

E. Operation and Maintenance Manuals: An updated as-built version of the control drawings and sequences of operation shall be included in the final equipment O&M manual submittal. The control drawings shall include:

1. A key to all abbreviations.
2. Graphic schematic depictions of the systems and each component.
3. Schematic system and component layout of any equipment that the control system monitors, enables or controls, even if the equipment is primarily controlled by packaged or integral controls.
4. A full points list with at least the following included for each point:

    a. Controlled system
    b. Point abbreviation
    c. Point description (dry bulb temp, airflow, etc.)
    d. Display unit
    e. Control point or setpoint
    f. Monitoring point
    g. Intermediate point
    h. Calculated point

5. Detailed sequences of operation for each piece of equipment. They shall include, as applicable:

    a. An overview narrative of the system (1 or 2 paragraphs) generally describing its purpose, components and function.
    b. All interactions and interlocks with other systems.
    c. Detailed delineation of control between any packaged controls and the building management system, listing what points the BMS monitors only and what BMS points are control points and are adjustable.
    d. Written sequences of control for packaged controlled equipment. Equipment manufacturers' stock sequences may be included. Provide additional narrative where needed.
    e. Start-up, warm-up mode, normal operating, emergency operating and shutdown sequences.
    f. Capacity control sequences and equipment staging.
    g. Temperature and pressure control: setbacks, setups, resets, etc.
    h. Detailed sequences for all control strategies, e.g., optimum start/stop, staging, optimization, demand limiting, etc.
    i. Effects of power or equipment failure with all standby component functions.
    j. Sequences for all level of alarms and emergency shut downs.
    k. Seasonal operational differences and recommendations.

l. Initial and recommended values for all adjustable settings, setpoints and parameters that are typically set or adjusted by the operating staff; and any other control settings or fixed values, delays, etc. that will be useful during testing and operating the equipment.

F. After final occupancy and all debugging have occurred, the Contractor shall prepare two (2) copies of all control software on non-volatile magnetic media and deliver them to the Owner.

1.7 SYSTEM TESTING

A. The controls contractor shall prepare a written plan indicating in a step-by-step manner, the procedures that will be followed to test, checkout and adjust the control system prior to and during functional performance testing. At minimum, the plan shall include for each type of equipment controlled by the automatic controls:

1. System name.
2. List of devices.
3. Step-by-step procedures for testing each controller after installation, including:

   a. Process of verifying proper hardware and wiring installation.
   b. Written program of sequence for BAS devices and controllers
   c. Process of downloading programs to local controllers and verifying that they are addressed correctly.
   d. Process of performing operational checks of each controlled component.
   e. Plan and process for calibrating valve and damper actuators and all sensors.
   f. A description of the expected field adjustments for transmitters, controllers and control actuators should control responses fall outside of expected values.

4. A copy of the log and field checkout sheets that will document the process. This log must include a place for initial and final read values during calibration of each point and clearly indicate when a sensor or controller has “passed” and is operating within the contract parameters.
5. A description of the instrumentation required for testing.
6. Indicate what tests on what systems should be completed prior to Testing, Adjusting and Balancing (TAB) using the control system for TAB work. Coordinate with the Owner and TAB contractor for this determination.

B. Upon completion of the checkout of each controlled device, equipment and system prior to functional testing for each piece of equipment or system, provide a signed and dated certification to the Owner and GC that all system programming is complete as to all respects of the Contract Documents, except functional testing requirements.

C. List and clearly identify on the as-built duct and piping drawings the locations of all static and differential pressure sensors (air and water pressure).

D. At the termination of the testing period, the Contractor shall provide completed point verification sheets for each point in the FMS. These sheets shall be included as a part of the closeout notebook described in Section 23 0900-3.3-7. An example of a point verification form is included in Appendix C.

E. Trend logs and graphs shall be developed as described in Section 23 0900-3.3-7 and Appendices A and B. Completed trend requirements shall be compiled into organized notebook(s) and delivered to the Engineer for approval before the final inspection and close-out of the project is performed.

F. The Owner reserves the right to participate in or assign a representative to participate in the startup, testing, programming, or any other aspect of the construction of this project at no additional cost to the Owner.

1.8 TRAINING

A. The controls contractor shall have the following training responsibilities, in addition to any listed in Division 1:

1. The standard operating manual for the system and any special training manuals will be provided for each trainee, with three extra copies left for the Owner. In addition, copies of the system technical manual will be demonstrated during training and one copy submitted with each O&M manual. Manuals shall include detailed description of the subject matter for each session. The manuals will cover all written control sequences and have a definitions section that fully describes all relevant words used in the manuals and in all software displays. Manuals will be approved by the Owner. Copies of audiovisuals shall be delivered to the Owner.
2. The training will be tailored to the needs and skill-level of the trainees.
3. The trainers will be knowledgeable on the system and its use. For the on-site sessions, the most qualified trainer(s) will be used. The Owner shall approve the instructor prior to scheduling the training.
4. There shall be three training sessions:

a. Training I. Class Room. The first training shall consist of **[8]** hours of actual training. This training shall be held on-site. If held off-site, the training may occur prior to final completion of the system installation. Upon completion, each student, using appropriate documentation, should be able to perform elementary operations and describe general hardware architecture and functionality of the system.

b. Training II. Hands -On. The second session shall be held on-site for a period of **[8]** hours of actual hands-on training after the completion of system QA. The session shall include instruction on:

1) Specific hardware configuration of installed systems in this building and specific instruction for operating the installed system, including HVAC systems, lighting controls and any interface with security and communication systems.

2) Security levels, alarms, system start-up, shut-down, power outage and restart routines, changing setpoints and alarms and other typical changed parameters, overrides, freeze protection, manual operation of equipment, optional control strategies that CAN be considered, energy savings strategies and set points that if changed will adversely affect energy consumption, energy accounting, procedures for obtaining vendor assistance, etc.

3) All trending and monitoring features (values, change of state, totalization, etc.), including setting up, executing, downloading, viewing both tabular

and graphically and printing trends. Trainees will actually set-up trends in the presence of the trainer.

4) Every screen shall be completely discussed, allowing time for questions.
5) Use of keypad or plug-in laptop computer.
6) Use of remote access to the system via phone lines or networks.

c. Training III. The third training will be conducted on-site six months after occupancy and consist of **[4]** hours of training. The session will be structured to address specific topics that trainees need to discuss and to answer questions concerning operation of the system.

A. The FMS supplier shall provide 20 hours total of on-line user support to assist the Owner in operating his system during the warranty period (this is not to be used to troubleshoot system problems unless said problems have to do with user programming) and 4 hours a month of additional on-site training during the warranty period. The Owner shall receive monthly statements indicating hours of on-line support used by which operators and for what purpose.

1.9 SERVICE AND WARRANTY

A. The system supplier shall maintain a local maintenance support facility complete with system technicians, diagnostic and test equipment, and new spare components. Emergency service shall be available in the local office on a 24-hour, 7-day a week basis. The service agent shall provide a continuously monitored local service telephone number for emergency service and this number shall be provided to the Owner.

B. Warranty all work as follows:

1. Labor & materials for control system specified shall be warranted free from defects for a period of twelve (12) months after final completion acceptance by the Owner. Control System failures during the warranty period shall be adjusted, repaired, or replaced at no charge or reduction in service to the Owner. Service during this period shall be available within 12-hours from the time the trouble call is placed.
2. At the end of the final start-up/testing, if equipment and systems are operating satisfactorily to the Owner and Engineer, the Owner shall sign certificates certifying that the control system's operation has been tested and accepted in accordance with the terms of this specification. The date of Owner's acceptance shall be the start of warranty.
3. Operator workstation software, project specific software, graphics, database, and firmware updates shall be provided to the Owner at no charge during the warranty period. Written authorization by Owner must, however, be granted prior to the installation of such changes.
4. The system provider shall provide a web-accessible system and support on-line resource that provides the Owner access to a question/answer forum, graphics library, user tips, upgrades, and manufacturer training schedules.

1.10 OWNERSHIP OF PROPRIETARY MATERIAL

A. All project-developed hardware and software shall become the property of the Owner. These items include but are not limited to:

1. Project graphic images

2. Record drawings
3. Project database
4. Project-specific application programming code
5. All documentation

1.11 PROGRESS PAYMENTS

A. When developing a schedule of values for the FMS and control systems, a minimum of 20% shall be reserved for activities after construction completion, including commissioning support, testing (functional performance testing and trend logs as required herein), record drawings, training, etc. Payment for these activities may be requested as they are completed.

PART 2 - PRODUCTS

2.1 GENERAL

A. All products required for this project shall be selected in accordance with this part of the Section. Installation of the components shall be in accordance with Part 3 of the Section. If a component is required to meet the requirements shown on the Drawings and is not specified in the Part of the Specification, the supplier shall select and submit on components that meets all design requirements indicated on the Drawings, stated in the sequence of operation, and elsewhere in the Contract Documents.

2.2 PRIMARY OPERATOR WORKSTATIONS

A. One (1) primary operator workstation/ server shall be provided including all necessary hardware and software requirements described herein. The workstation shall be connected to the FMS local area network directly.

B. Hardware Requirements

1. The minimum hardware requirements for the operator workstation shall include the following minimum requirements but in any case shall be of adequate capacity to easily accommodate the FMS software:

    a. Desktop Computer with the latest Intel processor released in the past six months and a standard 102-key keyboard.
    b. 160.0 Gbyte hard drive, read/write DVD
    c. 256 Mbyte RAM minimum.
    d. High resolution 24" LCD monitor and graphics adapter with 16 Mbyte memory minimum.
    e. Serial Mouse or PS/2 Microsoft compatible mouse.
    f. ETHERNET® Card and USB ports.

2. One (1) color LaserJet printer shall be provided for connection to the primary operator workstation.

3. The primary operator workstation[s] shall be used only as an interface to the LAN and shall in no way be necessary for the routine functioning of the FMS local area network or any FMS controller operation.
4. Any and all additional interface equipment necessary to connect the Operator Workstation to the FMS network.

C. Web Access

1. Web-Based Access to FMS System:

   a. FMS software shall be based on server thin-client architecture, designed around open standards of Web technology. The FMS server shall be accessed using a Web browser over FMS network, using Owner's LAN, and remotely over Internet.
   b. Intent of thin-client architecture is to provide operators complete access to FMS via a Web browser. No special software other than a Web browser shall be required to access graphics, point displays, and trends; to configure trends, points, and controllers; and to edit programming.
   c. Web access shall be password protected.

2. Web-Compatible Access to FMS System:

   a. Workstation/ server shall perform overall system supervision and configuration, graphical user interface, management report generation, and alarm annunciation.
   b. The FMS shall support Web browser access to building data. Operator using a standard Web browser shall be able to access control graphics and change adjustable set points.
   c. Web access shall be password protected.

D. Software Requirements

1. The operating system for the operator workstation**[s]** shall be the latest version of Microsoft Windows released in the past six months.
2. Software shall be provided for the operator workstation**[s]** which will allow operators to conduct business on the LAN simultaneously with any FMS controller in a full multi-user mode of operation. The following requirements define the minimum features which shall be provided as part of the Scope of Work of this Section.

   a. Operator Interface

      The primary operator workstation interface software shall minimize operator training through the use of English language prompting, English language point identification, and industry standard PC application software.

      The operator interface shall minimize the use of a typewriter-style keyboard through the use of a mouse or similar pointing device, and "point and click" approach to menu selection. The users shall be able to start and stop equipment, change schedules, or change setpoints from graphical displays through the use of a mouse or similar pointing device.

      At the option of the user, operator workstations shall provide consistent graphical or text-based displays of all system point and application data described in this Specification. Point identification, engineering units, status indication, and application naming conventions shall be the same at all operator devices.

      The operator interface shall provide the ability to simultaneously view several

different types of system displays in a windowing environment to speed facility operation and analysis. For example, the interface shall provide the ability to simultaneously display a graphic depicting an air handling unit, while displaying the trend graph of several associated space temperatures to allow the user to analyze system performance.

User-definable, automatic log-off timers of from 1 to 60 minutes shall be provided to prevent operators from inadvertently leaving devices online.

b. User Access

Multiple-level password access protection shall be provided to allow the user/manager to limit workstation control, display and data base manipulation capabilities as he/she deems appropriate for each user, based upon an assigned password.

A minimum of five (5) levels of access shall be supported and a minimum of 50 passwords shall be supported at each FMS panel.

Operators will be able to perform only those commands available for their respective passwords. Menu selections displayed at any operator device, including portable or panel-mounted devices, shall be limited to only those items defined for the access level of the password used to logon.

c. System Interaction

The operator interface shall allow the operator to perform commands within any FMS controller on the FMS local area network including, but not limited to, the following:

- Startup or shutdown selected equipment.
- Adjust setpoints.
- Add/modify/delete time programming.
- Enable/disable process execution.
- Lock/unlock alarm reporting for each point.
- Enable/disable totalization for each point.
- Enable/disable trending for each point.
- Override PID loop setpoints.
- Enter temporary override schedules.
- Define holiday schedules.
- Change time/date.
- Enter/modify analog alarm limits.
- Enter/modify analog warning limits.
- View limits.
- Enable/disable demand limiting for each meter.
- Enable/disable duty cycle for each load.

All control strategies and energy management routines shall be definable by the operator. System definition and modification procedures shall not interfere with normal system operation and control.

The system shall be provided complete with all equipment and documentation necessary to allow an operator to independently perform the following functions:

- Add/delete/modify standalone FMS panels.
- Add/delete/modify operator workstations.
- Add/delete/modify application specific controllers.
- Add/delete/modify points of any type, and all associated point parameters, and tuning constants.
- Add/delete/modify alarm reporting definition for each point.

- Add/delete/modify control loops.
- Add/delete/modify energy management applications.
- Add/delete/modify time- and calendar-based programming.
- Add/delete/modify totalization for every point.
- Add/delete/modify historical data trending for every point.
- Add/delete/modify custom control processes.
- Add/delete/modify any and all graphic displays, symbols, and cross-references to point data.
- Add/delete/modify dial-up telecommunication definition.
- Add/delete/modify all operator passwords.
- Add/delete/modify alarm messages.
- Add/delete/modify all FMS programs operating within the FMS panels and system.

Definition of operator device characteristics, FMS panels, individual points, applications and control sequences shall be performed through fill-in-the-blank templates.

d. Reports

Reports shall be generated automatically or manually, and directed at operator input to either CRT displays, printers, or disk files. As a minimum, the system shall allow the user to easily obtain the following types of reports:

- A general listing of all points in the network.
- List all points currently in alarm.
- List of all off-line points.
- List all points currently in override status.
- List of all disabled points.
- List all points currently locked out.
- List of all items defined in a "follow-up" file.
- List all weekly schedules.
- List all holiday programming.
- List of limits and deadbands.

Summaries shall be provided for specific points, for a logical point group, for a user-selected group or groups, or for the entire facility without restriction due to the hardware configuration of the facility management system.

e. Third Party Interface

System data, including transactions, trends, alarms, totalization files, etc., shall be stored on the workstation disk drive in an industry standard database format (e.g., dBase IV) such that it is compatible with off-the-shelf third party database and spreadsheet programs.

f. Dynamic Color Graphic Displays

Color graphic site plans, buildings, building floor plan displays, and system schematics for each piece of mechanical equipment, including air handling units, chilled water systems, hot water boiler systems, and all other controlled or monitored systems shall be provided as specified in Part 3 of this Specification.

Dynamic point (actual or calculated) indication shall be shown in their respective locations, and shall automatically update to represent current conditions without operator intervention.

The windowing environment of the operator workstation shall allow the user to simultaneously view several graphics at the same time.

g. Graphic Generation Software

Graphic generation software shall be provided to allow the user to add, modify, or delete system graphic displays.

A complete standard library of pre-engineered screens and symbols depicting standard air handling unit components (e.g., fans, cooling coils, filters, dampers, etc.,) complete mechanical systems (e.g., constant volume-terminal reheat, VAV, etc.,) and electrical symbols.

The graphic development package shall use a mouse or similar pointing device in conjunction with a drawing program to allow the user to perform the following:

- Define symbols.
- Position and size symbols.
- Define background screens.
- Define connecting lines and curves.
- Locate, orient and size descriptive text.
- Define and display colors for all elements.
- Establish correlation between symbols or text and associated system points or other displays.

h. Database Save/Restore/Backup

Backup copies of all standalone FMS panel databases shall be stored in the operator workstations. Continuous supervision of the integrity of all FMS panel databases shall be provided. In the event that any FMS panel on the network experiences a loss of its database for any reason, the system shall automatically download a new copy of the respective database to restore proper operation. Database backup/ download shall occur over the local area network without operator intervention. Users shall also have the ability to manually execute downloads of any or all portions of an FMS panel database to or from the operator workstation. The software shall support the use of a SQL database for information storage.

i. Trending and Trend Graphing

The software shall be capable of displaying realtime data from the FMS controllers or historical trend data retrieved from the operator workstation hard drive.

Capacity and features of the trending software and the associated trend graphing software shall be adequate to meet the requirements stated in Section 23 0900, 3.3 - 7 and as defined in Appendix A.

2.3 FMS CONTROLLERS

A. General

1. Standalone FMS controllers shall be microprocessor based, multi-tasking, multi-user, real-time digital control processors. Each standalone FMS controller shall consist of modular hardware with plug-in enclosed processors, communication controllers, power supplies, and input/output modules, volatile and non-volatile memory, signal conditioners, etc.
2. The FMS controllers shall have UL-916 or equivalent CSA or ETL listings. The FMS/FMS field modules shall also conform to FCC Docket 20780, Part 15, Subparagraph B.
3. The FMS controllers shall be fully compliant with ANSI/ASHRAE Standard 135-2012 BACnet and all published addenda at the time of installation.

B. Hardware Requirements

1. Communications

a. Each FMS Controller shall be equipped with the necessary hardware to permit connection to the FMS local area network described in this Section. All communications hardware shall be part of the standard manufactured product and no intermediary devices to establish communications shall be permitted.

2. Memory

a. Each FMS Controller shall have sufficient memory to support its own operating system and databases including:
   - Control processes.
   - Energy management applications.
   - Alarm management.
   - Historical/trend data for all points.
   - Maintenance support applications.
   - Custom processes.
   - Operator I/O.
   - Dial-up communications.
   - Manual override monitoring.

b. Non-volatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 72 hours.

c. Should FMS controller memory be lost for any reason, the panel will automatically receive a download via the local area network, phone lines, or connected computer. In addition, the user shall have the capability of reloading the FMS controller via the local area network, via the local RS-232C port, or via telephone line dial-in.

3. Input/Output

a. Each FMS controller shall support inputs and outputs of the following types:
   - Type C digital inputs.
   - SPDT digital outputs.
   - Universal analog inputs which support all industry standard signals including 4-20 mA, 0-20 ma, 0-10 VDC, etc.
   - Universal analog outputs which support all industry standard signals including 4-20 ma, 0-20 ma, 0-10 VDC, etc.
   - Pulse Type C digital inputs.
   - SPDT pulsed digital outputs.

4. Communication Ports

a. FMS controllers shall provide at least one RS-232C serial data communication ports for simultaneous direct connection of operator I/O devices including portable operator terminals (future) and printers. FMS controller shall allow connection to the serial ports without interrupting the normal operation of permanently connected modems, printers, or network terminals.

5. Override Switches

    a. Onboard hand/off/auto operator override switches shall be provided integral to the FMS controller for digital output points and positioning switches for all analog output points. The FMS controllers shall monitor the status or position of all overrides, and include this information in logs and summaries to inform the operator that automatic control has been inhibited.

6. Status Indicators

    a. The FMS controller shall have local status indication for each binary input and output without the need for an operator I/O device.

7. Surge and Transient Protection

    a. Isolation shall be provided at all network terminations, as well as all field point terminations to suppress induced voltage transients consistent with IEEE Standard 587-1980.

8. Expandability

    a. The system shall be modular in nature, and shall permit expansion through the addition of workstation hardware, FMS controllers, sensors, and actuators.

9. On-Line Diagnostics

    a. Each FMS controller shall continuously perform self-diagnostics, communication diagnosis and diagnosis of onboard electronics. The FMS controller shall provide both local and remote enunciation of any detected component failures or repeated failure to establish communication. Indication of the diagnostic results shall be provided at each FMS controller, and shall not require the connection of an operator I/O device.

10. Power Failure Restart

    a. In the event of the loss of normal power, there shall be an orderly shutdown of all standalone FMS controllers to prevent the loss of database or operating system software. Upon restoration of normal power, the FMS controller shall automatically resume full operation without manual intervention.

C. Software Requirements

1. General

    a. All necessary software to form a complete operating system as described in this Specification.
    b. All software routines and programs specified in this Section shall be provided as an integral part of the FMS controller and shall not be dependent upon any higher level computer for execution.

2. PID Control

a. The FMS controllers shall perform full proportional, integral, derivative (PID) control with all PID loops having the automatic control loop tuning feature.

3. Minimum Runtimes

a. The control software shall include a provision for all digital outputs to have minimum on/off cycle filters.

4. Staggered Starts

a. The control software shall include a provision for all digital outputs to electrical demand base start filters to prevent excessive electrical demand on the startup of equipment.

5. Automatic Restart

a. After an interruption of normal power, the FMS controller shall analyze the status of all controlled equipment, compare it with the commanded position and return all equipment ON or OFF as necessary to resume normal operation.

6. Energy Management Applications

a. The FMS controllers shall have the ability to perform all of the following energy management routines as standard sub-routines which do not require the application of customized software:
   - Time of day scheduling.
   - Calendar-based scheduling.
   - Holiday scheduling.
   - Temporary schedule overrides.
   - Optimal start.
   - Optimal stop.
   - Night setback control.
   - Enthalpy switchover (Economizer).
   - Peak demand limiting.
   - Temperature compensated duty cycling.
   - Chiller sequencing.

b. All programs shall be executed automatically without the need for operator intervention, and shall be flexible enough to allow operator customization. Programs shall be applied to building equipment as described in the Sequence of Operation.

D. Custom Programming

1. The FMS controllers shall be able to execute custom, job-specific processes defined by the operator, to automatically perform calculations and special control routines.
2. There shall be no restriction as to the ability of the operator to create any type of control logic using system inputs, calculated variables, Boolean Logic, etc.
3. The software shall be able to generate operator messages and advisories to operator I/O devices. A process shall be able to directly send a message to a specified primary

operator station or printer, buffer the information in a follow-up file, or cause the execution of a dial-up connection to a remote operator workstation.

E. Alarm Management

1. Alarm management shall be provided to monitor, buffer, and direct alarm reports to operator devices and memory files. Each FMS controller shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic, and prevent alarms from being lost. At no time shall the FMS controller's ability to report alarms be affected by either operator activity at an Operator Workstation or local I/O device, or communications with other panels on the network.
2. The user shall be able to define the specific system reaction for each point. Alarms shall be prioritized to minimize nuisance reporting and to speed operator response to critical alarms. A minimum of three (3) priority levels shall be provided. Each FMS controller shall automatically inhibit the reporting of selected alarms during system shutdown and startup. Users shall have the ability to manually inhibit alarm reporting for each point.
3. In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a 65-character alarm message to more fully describe the alarm condition or direct operator response.
4. Each FMS controller shall be capable of storing a library of at least 250 alarm messages. Each message may be assignable to any number of points in the panel.

F. Report Routing

1. Alarm reports, messages, and files will be directed to a user-defined list of devices or disk files used for archiving alarm information.

G. Operator Log

1. Operator commands and system events shall be automatically logged to disk in personal computer industry standard database format. Operator commands initiated from direct-connected workstations, dial-up workstations, and local FMS controller network terminal devices shall all be logged to this transaction file. This data shall be available at the Operator Workstation. In addition, this transaction file shall be accessible with standard third party database and spreadsheet packages. The user shall also be able to define under which conditions point changes need to be acknowledged by an operator, and/or sent to follow-up files for retrieval and analysis at a later date.

H. Trend Analysis

1. The FMS controllers shall be capable of storing point history files for every analog and binary input and output at the same time. The point history routine shall continuously and automatically sample the value of all analog inputs at user definable intervals.
2. The FMS controllers shall also provide high resolution sampling capability in one-second increments for verification of control loop performance.
3. Trend data for the FMS controller as well as all associated ASCs and TCUs shall be stored at the FMS controllers, and uploaded to hard disk storage at the operator workstation when archival is desired. Uploads shall occur based upon either user-defined interval, manual command, or when the trend buffers become full. All trend data shall be available in disk file format compatible with third party personal computer applications.

I. Runtime Totalization

1. The FMS controllers shall automatically accumulate and store runtime hours for binary input and output points as specified in the Execution portion of this Specification.
2. The totalization routine shall have a sampling resolution of one (1) minute or less.
3. The user shall have the ability to define a warning limit for runtime totalization. Unique, user-specified messages shall be generated when the limit is reached.
4. The FMS controllers shall automatically sample, calculate and store consumption totals on a daily, weekly, or monthly basis for user-selected analog and binary pulse input-type points.

J. Event Totalization

1. Standalone FMS controllers shall have the ability to count events such as the number of times a pump or fan system is cycled on and off. Event totalization shall be performed on a daily, weekly, or monthly basis.
2. The event totalization feature shall be able to store the records associated with a minimum of 9,999,999 events before reset.
3. The user shall have the ability to define a warning limit. Unique, user-specified messages shall be generated when the limit is reached.

2.4 APPLICATION SPECIFIC CONTROLLERS

A. Each FMS controller shall be able to extend its performance and capacity through the use of remote Application Specific Controllers (ASC). The ASC shall be selected to match the function required. In no case shall multiple ASCs be used for one piece of mechanical hardware or an entire system (HW or CW system) in an effort to increase point or memory capacity. If one ASC is unable perform all aspects of monitoring or control for any given piece of equipment or system, a FMS controller or more applicable ASC shall be applied.

B. Each ASC shall operate as a standalone controller on a sub-LAN and shall be capable of performing its specified control responsibilities independently of other controllers on the network. Each ASC shall be a microprocessor-based, multi-tasking, real-time digital control processor.

C. Each ASC shall have sufficient memory to support its own operating system and data bases for control routines, energy management applications, and operator I/O points.

D. The operator interface to any ASC point data or programs shall be through an operator workstation or from a portable operators terminal.

E. Power failure protection for all system setpoints, proportional bands, control algorithms, and any other programmable parameters shall be stored such that a power failure of any duration does not necessitate reprogramming the controller.

F. All ASC controllers shall be fully compliant with ANSI/ASHRAE Standard 135-2012 BACnet and all published addenda at the time of installation.

2.5 TERMINAL UNIT CONTROLLER

A. A Terminal Unit Controller (TUC) shall be provided for each terminal unit as indicated on the Drawings and as listed in the equipment schedule. The TUCs shall be connected as part of a LAN or sub-LAN which shall communicate at not less than 9600 Baud. Each terminal unit controller shall communicate on a peer-to-peer basis with all units having equal authority. Provide a TUC space temperature sensor for each TUC.

B. Each TUC shall execute application programs, calculations, and commands via a microcomputer resident on the TUC. The database and all application programs for each TUC shall be stored in readable/writeable non-volatile memory within the TUC.

C. Each TUC shall contain both software and hardware to perform full DDC/PID control loops. TUCs shall be able to provide analog output, in addition to normal binary type output.

D. Each TUC shall be able to support various types of zone temperature sensors, including temperature sensor only, temperature sensor with built-in local override switch, with setpoint adjustment switch.

E. Each TUC for VAV application shall have built-in air flow transducers for accurate airflow measurement of discharge air flow in order to provide the pressure independent VAV operation.

F. Each TUC shall have a built-in detection circuit to monitor the presence of the power to the equipment, and in case of the absence of the power it shall generate on alarm to the Operator Workstation.

G. Each TUC shall have LED indication for visual status of communication, power, and all outputs. All circuits shall be optically isolated.

H. All TUC controllers shall be fully compliant with ANSI/ASHRAE Standard 135-2012 BACnet and all published addenda at the time of installation.

2.6 OPERATOR INTERFACE PANELS

A. The operator interface panel shall be a permanently mounted LCD display with keypad or touchscreen system. The LCD shall have a minimum of 80 characters on multiple lines. The operator interface panel shall connect directly to the FMS controller LAN or controller. Portable handheld devices shall not be approved.

B. The operator interface shall allow the operator to perform commands within any FMS controller on the FMS local area network including, but not limited to, the following:

- Startup or shutdown selected equipment.
- Adjust setpoints.
- Add/modify/delete schedules.
- Enable/disable process execution.
- Acknowledge alarms.
- Enable/disable totalization for each point.
- Enter temporary override schedules.

- Define holiday schedules.
- Change time/date.
- Enter/modify analog alarm limits.
- Enter/modify analog warning limits.
- View limits.
- Change password protection.

2.7 NETWORKING/COMMUNICATIONS

A. Primary Local Area Network (LAN)

1. The only FMS equipment connections to the primary LAN are the FMS controllers or routers and the operator workstations. All other FMS hardware shall reside on either the Controller LAN or the sub-controller LAN.
2. All FMS devices that reside on the primary LAN shall be compatible with the ETHERNET®.

B. FMS Controller Network (LAN)

1. FMS controllers (if not on the primary LAN) and application specific controllers Interfaces within a specific building shall reside on the second tier LAN referred to as the controller LAN. The controller LAN shall begin at the building FMS controller or router and extend to one or more FMS controller LAN controllers located throughout the building.
2. Access to system data shall not be restricted by the hardware configuration of the network. The hardware configuration of the network shall be transparent to the user when accessing data or developing control programs.
3. Expansion of the network shall support any combination of FMS controllers.
4. The network shall include provisions for automatically re-configuring itself to allow all operational equipment to perform their designated functions as effectively as possible in the event of single or multiple failures. The local area network shall also provide for error detection, correction, and re-transmission to guarantee data integrity.
5. Communications must be of a deterministic nature to assure calculable performance under worst-case network loading at speeds no less than 9600 bps. No collision-based network shall be accepted below 10 Mbps.
6. Automatic synchronization of the real-time clocks in all FMS controllers shall be provided.
7. Development of the controller LAN is work provided entirely under this Section of the Specification.

C. Sub-Controller Local Area Network

1. All lower level controllers associated with terminal unit controllers shall reside on the third tier LAN referred to as the sub-controller LAN.
2. The sub-controller LAN shall operate RS-485 at a selectable speed of 9.6K or higher. Development of the sub-controller LAN is work provided entirely under this Section of the Specification.

D. All products shall be new and of the latest manufacturer's design. Warranty of all products shall

start on the date of final acceptance of the work.

E. All products shall be provided complete with all mounting hardware, brackets, and miscellaneous accessories whether stated in the individual product specification or not. Specific product options that are required to meet all design requirements indicated on the Drawings, stated in the sequence of operation, shown on the electrical ladder diagrams, and elsewhere in the contract documents shall be specified when the product is ordered and indicated on the catalog data sheet provided with the submittal.

2.8 DUCT STATIC PRESSURE STATION

A. Provide at each duct static pressure measuring location a traverse probe capable of continuous monitoring of static pressure. The probe shall contain multiple static pressure pickup points along the exterior surface of the cylindrical probe, internally connected to their respective averaging manifold. Each probe shall be extruded aluminum construction with threaded end support rod and nut, and mounting plate with gasket. Each probe shall be sized to span the entire duct and not extend past either side. The probe shall not produce a measurable pressure drop and shall produce a non-pulsating signal with an accuracy of 0.5 percent of total span. Air Monitor Model STAT-Probe/1 or equivalent.

2.9 OUTSIDE AIR STATIC PRESSURE PROBE

A. Outside air static pressure probe shall be constructed of 10 gage, anodized aluminum with a 2" diameter FPT connection. The probe shall be capable of sensing the outside atmospheric air pressure to within 2 percent of the actual value when subject to radial wind velocities up to 80 miles per hour with approach angles up to 30 degrees to the horizontal. Specification based on air monitor S.O.A.P.

2.10 ELECTRONIC DIFFERENTIAL PRESSURE TRANSMITTER

A. Electronic differential pressure transmitter shall be designed to measure the differential air pressure as indicated on the Drawings or as required. Pneumatic connections shall be 1/4" barbed and the enclosure shall be provided with holes for panel or field mounting. The output shall be a two wire 4-20 mA loop powered device with an input range as indicated in the Drawings but not more than twice the actual measure variable. The accuracy including linearity, hysteresis and repeatability shall be less than ±1 percent. Setra model C264 or equivalent.

2.11 ELECTRONIC TEMPERATURE ELEMENT AND TRANSMITTER

A. Zone Space Sensors

1. Each TUC or ASC controlling a single zone application shall be provided with a space temperature sensor. The space sensor shall include a thermistor packaged or RTD in the standard UC/sensor design, digital temperature display, timed override button, set point adjustment, and a maintenance communication port.

B. All Other Temperature Sensors

1. Thermistor temperature sensors connected to a TUC or an ASC shall be a Type II thermistor compatible with the attached FMS controller without the need for any signal conversion hardware. The accuracy of the thermistor shall be ±0.5 deg F over the range of the sensor. Precon ST series or equivalent.
2. RTD temperature sensors shall be 1000 ohm platinum having an accuracy of ±1 deg F over the entire range. The associated unit mounting transmitter shall generate a linear 4-20 mADC loop powered signal with a maximum input impedance of 675 ohms at 24 VDC.
3. Sensors used for mixed air application shall be 25' averaging type. The sensor span shall have a field set range of range of 32.0 deg F to 160.0 deg F.
4. All chilled water sensors and sensors placed in locations susceptible to condensation (outside or in chilled and condenser water liquid lines with the potential to drop below the ambient dew point) shall be furnished complete with a NEMA 3R enclosure for the electronics. The sensors shall have an immersion length of one half the pipe's diameter plus the length of the pipe tap. The sensors shall have a range of 10.0 deg F to +230.0 deg F. Units shall be furnished complete with a brass thermowell.
5. Duct temperature sensors for supply air temperatures and return temperature shall be a minimum of 18" in length. The sensor span shall have a range of -30.0 deg F to +160.0 deg F.
6. Sensors used for outdoor air temperature shall be provided complete with a sunshield. The sensor span shall have a range of -30.0 deg F to +140.0 deg F.
7. All immersion water, except chilled water sensors, shall have an immersion length of one half the pipe's diameter plus the length of the pipe tap. The sensors shall have a range of +10.0 deg F to +230.0 deg F. Units shall be furnished complete with a brass thermowell.
8. All temperature elements provided for space temperature measurement shall be installed in a white plastic housing.

2.12 AIR FLOW STATION AND TRANSMITTER

A. Pitot Tube Air Flow Element and Transmitter

1. Each airflow traverse probe shall contain multiple total and static pressure sensors located along the exterior surfaces of the cylindrical probe and internally connected to their respective averaging manifolds. The flow sensors shall not protrude beyond the surface of the probes, and shall be the offset type for static pressure and the chamfered impact type for total pressure measurement. The airflow sensing probe’s measurement accuracy shall not be affected by directional flow having pitch and/or yaw angles up to 30 degrees. Each airflow traverse probe shall be of extruded aluminum construction and furnished with mounting plates(s), gasket, and signal fittings suitable for HVAC duct installation.
2. Total and static pressure sensors shall be located at the centers of equal areas (for rectangular ducts) or at equal concentric area centers (for circular ducts) along the probe length.
3. Probes shall be AMCA certified and be capable of measuring the airflow rates within an accuracy of ±2 percent without the use of correction factors. The maximum allowable unrecovered pressure drop caused by the probes shall not exceed 0.025 inches WC at 2000 fpm or 0.085 inches WC at 4000 fpm. The number of probes required for each installation shall be in accordance with the manufacturer's design recommendations. The airflow traverse probes shall be Air Monitor Corporation Model VOLU-probe or

equivalent.

4. Pitot tube type air flow element flow stations shall not be used if the manufacturer's recommended upstream and downstream clearances cannot be achieved in the installation. The Contractor shall use thermal anemometer air flow stations in these instances.
5. All airflow transmitters shall be capable of receiving flow signals from the airflow traverse probe and producing an output linear and scaled for air volume. The transmitter shall contain an integral multi-line digital display for use during the configuration and calibration process, and to display one transmitter output during normal operating mode. All transmitter configuration, parameter setting, zero and span calibration, plus display formatting and scaling will be performed digitally in the on-board microprocessor via input pushbuttons. The transmitter will be available in multiple natural spans covering the range of 0.05 inches WC to 25.0 inches WC with an accuracy of 0.25 percent of natural span. The transmitter shall be furnished with a transducer automatic zeroing circuit and be capable of maintaining linear output signals on applications requiring 5 to 1 velocity turndown. Transmitter shall have a NEMA 12 enclosure. This Specification applies to all airflow transmitters. Transmitter shall be Air Monitor Corporation VELTRON DPT 2500-plus or equivalent.

B. Thermal Air Flow Station

1. Each probe array shall consist of one or more multi-point measuring probes and a single microprocessor based transmitter. The transmitter shall be supplied by the same manufacturer as the measuring station or probe array.
2. Each multi-point probe shall be assembled using heavy wall anodized aluminum tubing, aluminum mounting plates, aerodynamically optimized molded sensing apertures to ensure accurate measurement in angular airflow conditions, and neoprene mounting gasket.
3. The probe array shall be connected to the transmitter using a single cable, of up to 100' in length, included with the transmitter.
4. Each stand-alone sensing point shall use an ambient temperature thermistor and an externally heated thermistor to determine the point velocity and temperature. Automatic equal area averaging of the individual point measurements shall be performed in the transmitter.
5. Each airflow sensor shall have an operating range of 5,000 FPM, with a NIST traceable accuracy of ±2% of reading for velocity measurement and 0.1°F for temperature measurement.
6. The sensor density shall comply with the manufacturer’s recommendations based on the accuracy requirement and the size of duct the sensors are being installed in.
7. Individual sensors shall be fully field serviceable without need for field calibration, not requiring that the probe be returned to the Factory for repair and/or calibration.
8. Each transmitter shall be capable of averaging as many as thirty-two (32) sensors,
9. The transmitter will have a high visibility backlit LCD for display of either the averaged or individual sensor airflow and temperature measurements, in user selectable units of measure. The transmitter shall be factory configured to output duct air volume for plug and play operation.
10. All transmitter configuration, scaling, and diagnostic functions shall be performed by means of a password protected, cover mounted membrane keypad.
11. The transmitter outputs shall be dual analog (4-20mA, 0-5VDC or 0-10VDC) and BACnet MS/TP communication interface for airflow and temperature.
12. The operating temperature range of the transmitter shall be from -20° to 140°F. The

transmitter shall be located where it will be sheltered from water or weather.

13. Input power to each transmitter shall be 24VAC/24VDC.
14. The transmitter shall be provided with interconnect cable for remote mounting up to 100' away.
15. When installed per the manufacturer's minimum installation requirements, the transmitter with accompanying station or probe array shall measure with an accuracy of ±2-3% of actual flow.
16. The Airflow Measuring System shall be the ELECTRA-flo Plus as manufactured by Air Monitor Corporation or equivalent.

2.13 ELECTRONIC HUMIDITY TRANSMITTER

A. The sensors shall have an accuracy better than ± 2.0 percent R.H. over the range of 10 to 90 percent R.H. with an operating temperature range of at least -20 to 60 deg C. The transmitter shall output a 4-20 mADC loop powered signal over the full range of the transmitter and the input impedance shall not exceed 500 ohms at 20 VDC. The transmitter shall be specifically designed for use in measuring outdoor or duct humidity or indoor space applications as indicated.

1. Outdoor or duct mounted units shall be enclosed in a NEMA 4 enclosure with a black painted aluminum casing. Vaisala Model No. HMD 60 or equivalent.
2. Space transmitters shall be KELE Vaisala Model No. HMW 90 or equivalent.

2.14 CURRENT TRANSDUCERS

A. Current sensing transducers shall measure AC current of loads and shall output a 4-20 mADC signal over the measured range of 0 to 60 amps AC. Sensor shall have a minimum of 2.0 percent of full scale accuracy. Unit shall be split core design. Veris Industries Model H-921 or equivalent.

2.15 CURRENT SENSING SWITCH

A. Current sensing relays shall indicate the status of AC current of motor loads. The transistor switches shall be rated for switching controller DC current up to 0.1 amp continuously at 30 VDC. The setpoint of the contact operation shall be field adjustable from 1 to 135 amps AC. The switch shall be self powering with a switched load LED for local indication. Veris Industries Model H908 or equivalent.

2.16 AIR DIFFERENTIAL PRESSURE SWITCHES

A. Filter/Fan Status Switch

1. Air differential pressure switches shall have an adjustable setpoint of from 0.05" W.C. to 12.0" W.C. One snap acting SPDT Type C switch shall be enclosed under a NEMA 1 enclosure with a 1/2" conduit opening. Contacts shall be rated for 10 amps at 120 VAC. Cleveland AFS series or equivalent.

B. Static Pressure Safety Switch

1. Air pressure switch shall be manually reset type, designed to sense static pressure and break an electrical circuit when the setpoint is exceeded. The setpoint shall be adjustable form 0.4" to 12" W.C. Unit shall be furnished and installed with a static pressure tip. Kele & Associates Model AFS-460 or equivalent.

2.17 ELECTRIC LINE VOLTAGE THERMOSTAT

A. The thermostat shall be of the bimetallic design with a SPDT set of contacts rated for 120 VAC at 25 amps. Thermostat shall have an adjustable set point of from 50 deg F to 86 deg F with a fixed differential of 2.0 deg F. The cover shall be metal. Barber-Coleman Model No. TC-195 or equivalent.

2.18 ELECTRIC LOW LIMIT (FREEZESTAT)

A. Freezestat shall have a 20' temperature-sensitive element designed to respond to the lowest temperature to which any 1' length of the element is exposed. The unit shall have an adjustable set point from 35 deg F to 45 deg F. The electrical rating of the two SPDT contacts shall be 10.2 full load amps at 120. Unit shall be complete with an external manual reset lever. Johnson A70 series or equivalent.

2.19 CONTROL RELAYS

A. Control relay contacts shall be rated for 150% of the loading application, with self-wiping, snap-acting silver cadmium Form C contacts, enclosed in dust-proof enclosure. Relays shall be equipped with the necessary mounting base, DIN rail, labels, termination clips, etc., and a coil transient suppression devices. All relays for control by the FMS shall have 24 VAC coils. All other required relays shall have coil voltages appropriate for the installation. IDEC RH series or equivalent.

2.20 CONTROL TRANSFORMERS

A. Control transformers shall be provided where shown or where required to meet the sequence of operation. Control transformers shall be fused on both primary and secondary taps. Fusing shall not exceed 80 percent of the rated transformer output. Control transformers 100 VA and less may have internal secondary overload if desired but anything over 100 VA must be external fused. Control transformers over 100 VA supplying power to a control panel shall be located external to the control panel.

2.21 AUTOMATIC DAMPERS

A. All automatic dampers, except for mixing box dampers furnished with air handling units as specified on the Equipment Schedule, shall be furnished under this Section of the Specifications. These dampers shall be installed and mounted under Section 23 3000.

B. Dampers shall be constructed of extruded aluminum with oilite bronze or Teflon bearings and trunnions of non-corrosive materials. Each blade shall have a positive closing butyl-rubber or neoprene edge seal, and spring-loaded side seals unless otherwise noted. Dampers shall have louvers designed so that the blades are interconnected to give parallel movement. Jack shafting shall be provided for all dampers greater than 24" by 24". Ruskin CD-50 or equivalent.

C. Parallel Blade Dampers: Provide parallel blade type automatic dampers for return air dampers, two-position dampers, the face section of face and bypass dampers, and where indicated on the Drawings.

D. Opposed Blade Dampers: Provide opposed blade type dampers for volume control, exhaust and outside air dampers of a mixing section, throttling application and where indicated on Drawings.

2.22 DAMPER ACTUATORS

A. Electronic Damper Actuators

1. The actuator shall be of the direct-coupled design. The fastening clamp assembly shall be of a V-bolt design with associated V-shaped toothed cradle attaching to the shaft for maximum strength and eliminating slippage. Spring return actuators shall have a V-clamp assembly of sufficient size to be directly mounted to an integral jack shaft of up to 1.05 inches when the damper is constructed in this manner. Actuators shall be designed for a minimum of 60,000 full stroke cycles at the actuator's rated torque and shall have a two (2) year manufacturer's warranty, starting from the date of installation.
2. The actuator shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the entire rotation of the actuator. Mechanical end switches or magnetic clutch to deactivate the actuator at the end of rotation are not acceptable. For power-failure/safety applications, an internal mechanical spring return mechanism shall be built into the actuator housing. Non-mechanical forms of fail-safe operation are not acceptable.
3. Spring return actuators shall be provided for all outside and exhaust/relief air dampers in addition to all locations indicated on the Drawings. Spring return actuators shall be capable of both clockwise and counterclockwise spring return operation by simply changing the mounting orientation.
4. Proportional actuators shall accept a 0 - 10 VDC or 0 - 20 mA control input and provide a 2 - 10 VDC or 4 to 20 mA operating range. All actuators shall provide a 2 - 10 VDC position feedback signal and shall have an external, built-in switch to allow the reversing of direction of rotation.
5. All actuators shall not require more than 10 VA regardless of the operating voltage.
6. All non-spring return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring return actuators with more than 60 in/lb torque capacity shall have a manual crank.
7. Actuators shall be provided with a conduit fitting and a minimum three-foot electrical cable and shall be pre-wired to eliminate the necessity of opening the actuator housing to make electrical connections.
8. Actuators shall be Underwriters' Laboratories Standard 873 listed and Canadian Standards Association Class 481302 certified as meeting correct safety requirements and recognized industry standards.
9. Manufacturer shall be ISO9001 certified. Actuators shall be manufactured by BELIMO

or equivalent.

2.23 CONTROL VALVES

A. Ball Control Valves Three Inches and Less.

1. Two-way control valves shall be industrial quality with bronze bodies and female NPT threads. Valve bodies may also be stainless steel, titanium or nickel with operating pressure up to 2000 psi. The maximum operating differential shall be 5 psi for water.
2. All valves shall have blowout proof stem design, glass-reinforced Teflon thrust seal washer and stuffing box ring with minimum 600 psi rating. Stem packing gland screw shall be adjustable for wear.
3. Standard chromium plated stainless steel ball and stem, shall be rated at a minimum of 600 psi WOG (water-oil-gas), cold, non-shock, and 150 psi for saturated steam service. All valves shall be provided with reinforced Teflon seats.
4. Belimo, Bray, or equivalent.

B. Two- and Three-Way Globe Control Valves Two Inches and Less.

1. Valves 1/2" through 2" shall be bronze, screw type, and shall be rated at 250 psi maximum working pressure for water and steam.
2. Valve stems shall be stainless steel, highly polished, corrosion-resistant, alloy to decrease friction and increase response. Valve plugs shall be brass and guided to ensure perfect seating.
3. Stem packing shall be spring loaded EP V-rings for water applications and Teflon V-rings for steam applications to eliminate leakage around the stem and ensure a minimum amount of stem friction. Stem lift shall be 1/2" to 3/4".
4. Flow type shall be equal percentage for water. The maximum operating differential shall be 5 psi for water.
5. Composition discs shall be replaceable and provide tight shutoff.
6. Belimo, Bray, or equivalent.

C. Two- and Three-Way Globe Control Valves Greater than Two Inches.

1. Valves 2-1/2" through 6" shall be cast iron flanged, and rated at 125 psi maximum working pressure. The maximum working temperature shall be 300 deg F/149 deg C.
2. Valve plug stems shall be stainless steel, highly polished, corrosion-resistant, alloy to decrease friction and increase response. Valve plugs shall be brass and guided to ensure perfect seating. Stem packing shall be Teflon, spring loaded EP V-rings to eliminate water leakage around the stem and ensure a minimum amount of stem friction. Lift shall be 3/4" to 1-1/2".
3. Flow type shall be equal percentage. The maximum recommended differential shall be 5 psi for water.
4. Composition discs shall be replaceable and provide tight shutoff.
5. Belimo, Bray, or equivalent.

2.24 CONTROL VALVE ACTUATORS

A. Electronic Globe and Ball Valve Actuators

1. Ball valves actuator shall be fully modulating using 2-10 VDC or 4-20 mADC, floating point, two-position spring return as indicated in the control sequence. Fail safe, where specified, shall require mechanical spring return. The actuator shall be positive positioning, responding to a 2-10 VDC or 4-20 mA signal (with the addition of a 500 ohm resistor). There shall be a visual valve position indicator. Power shall be 24 VAC unless indicated otherwise on the Drawings and shall not exceed 8 watts at 24 VAC. A 3-foot cable shall be provided for easy installation to an electrical junction box. The actuator shall provide minimum torque required for proper valve close-off, with an approximate running time of two (2) minutes for full rotation. The actuator shall be designed with current limiting motor protection. (End of travel switches and magnetic clutches are not acceptable.) A release button on the actuator shall be provided to allow for manual override, except when utilizing spring return actuators.
2. Ball Valves: All actuators shall be UL listed. The manufacturer shall warranty all the actuators and valve assemblies for a period of two (2) years from date of installation.
3. The actuators and valves shall be factory mounted and tested and supplied. Belimo, Bray, or equivalent.

2.25 ELECTRICAL CONTROL POWER AND LOW VOLTAGE WIRING

A. Provide interlock wiring between supply and exhaust fans, electrical wiring for relays (including power feed) for temperature and pressure indication. Provide interlock wiring between refrigeration machines, pumps and condensing equipment as required for the specified sequence of operation and the refrigeration system integral controller(s). Do not provide interlock wiring if a dedicated digital output has been specified for the equipment or the sequence of operation requires independent start/stop.

B. Provide power wiring, conduit and connections for low temperature thermostats, high temperature thermostats, alarms, flow switches, actuating devices for temperature, humidity, pressure and flow indication, point resets and user disconnect switches for electric heating, appliances controlled by the FMS.

C. Provide all other wiring required for the complete operation of the specified systems including control power wiring not expressly stated to be provided by Division 26.

D. Install all wiring raceway systems complying with the requirements of the National Electrical Code and Division 26. All installations shall be installed in EMT.

E. FMS Network Communication Requirements

1. Wired network communication shall be via channels consisting of communications wire installed in a 3/4" EMT or of plenum cable installed in the ceiling as outlined in other parts of this specification.
2. Telephone lines, where required as a remote communication source, shall utilize voice band, non-switched, private line channels consistent with Bell Systems Technical Reference Publication 41001 and shall be four-wire unconditioned 3002 channels. The modems shall have 25 pin EIA connectors and RS-232C interface.

3. Communication conduits and wiring shall not be installed closer than six feet from high power transformers or run parallel within six feet of electrical high power cables. Care shall be taken to route the cable as far from interference generating devices as possible.
4. All shields shall be ground (earth ground) at one point only, to eliminate ground loops.
5. There shall be no power wiring, in excess of 30 VAC rms, run in conduit with communications wiring. In cases where signal wiring is run in conduit with communication wiring, all communication wiring and signal wiring shall be run using separate twisted shielded pairs (24 AWG) with the shields grounded in accordance with the manufacturer's wiring practices.

F. Power and Communication Wiring Transient Protection

1. The control manufacturers shall submit catalog data sheets providing evidence that all FMS products offered by the manufacturer are tested and comply with the standard for Transient Surge withstand capabilities for electrical devices ANSI C62.41, IEEE-587-1980, Categories A and B. Such testing shall have included power and communication trunk wiring. Compliance with IEEE-587 shall imply conformance with IEEE-472 transient standards based on the stated position of ANSI and IEEE regarding applicability of the rated standards.
2. Communications trunk wiring shall be protected with a transient surge protection device providing the minimal protection specifications of the General Semiconductor, Model #422E device.
3. The communications circuitry, input/output circuitry, and CUs, shall provide protection against a 1000 volt, 3 amp transient signal, directly applied to the communication or input/output terminations. The manufacturer’s catalog data sheet shall provide evidence of conformance with this requirement. Systems not complying with this requirement shall provide equivalent protection external to the FMS controller. Protection shall be provided for the individual communications and input/output terminations for each FMS controller. Submittal documentation shall clearly define how this requirement will be met and how the external protection will not affect the performance of the controllers.

G. Input/Output Control Wiring

1. RTD wiring shall be three-wire or four-wire twisted, shielded, minimum number 22 gage.
2. Other analog inputs shall be a minimum of number 22 gage, twisted, shielded.
3. Binary control function wiring shall be a minimum of number 18 gage.
4. Analog output control functions shall be a minimum of number 22 gage, twisted, shielded.
5. Binary input wiring shall be a minimum of number 22 gage.
6. Thermistors shall be equipped with the manufacturer's calibrated lead wiring.
7. 120V control wiring shall be #14 THHN in 3/4" conduit. Provide 4 or 20 percent fill extra wire in each conduit.

H. Splices

1. Splices in shielded cables shall consist of terminations and the use of shielded cable couplers which maintain the integrity of the shielding. Terminations shall be in accessible locations. Cables shall be harnessed with cable ties as specified herein.

I. Conduit and Fittings

1. Conduit for Control Wiring, Control Cable and Transmission Cable: Electrical metallic tubing (EMT) with compression fittings, cold rolled steel, zinc coated or zinc-coated rigid steel with threaded connections.
2. Outlet Boxes (Dry Location): Sheradized or galvanized drawn steel suited to each application, in general, four inches square or octagon with suitable raised cover.
3. Outlet Boxes (Exposed to Weather): Threaded hub cast aluminum or iron boxes with gasket device plate.
4. Pull and Junction Boxes: Size according to number, size, and position of entering raceway as required by National Electrical Codes. Enclosure type shall be suited to location.

2.26 AIR PIPING

A. Hard tubing shall be copper connected with sweat or compression fittings.

B. Plastic tubing shall be specifically designed for use with control systems. The tubing shall be resistant to ultraviolet breakdown, stress cracking and shall meet all requirements for fire retardant smoke propagation as required by applicable codes and regulations.

C. Tubing run in walls from thermostats to equipment above the ceiling shall meet the Specifications of plastic tubing stated previously but shall have an additional armored jacket to prevent chafing on stud and plated penetrations.

2.27 SMOKE AND FIRE DETECTORS

A. Smoke detectors shall be supplied, powered, installed, and interlocked in accordance with Section 23 0549. The smoke detectors shall be listed by Underwriters' Laboratories, Inc. The units shall be designed for detection of combustion gases, fire and smoke in air conditioning and ventilation system ducts, in compliance with the National Fire Protection Association, Recommended Practices Pamphlet No. 90A. It shall consist of an ionization type detector with self-contained control unit. The assembly shall consist of a casting to accommodate metallic sampling tubes which extend across the duct of the ventilation system.

B. The unit shall provide two (2) sets of normally open single pole, double throw alarm operated relay contacts (5A, 120V, AC).

C. The unit shall be bolted directly to the duct or plenum wall. A template shall be provided for making necessary cutouts and holes. Complete instructions shall be provided with units.

D. Unit shall be capable of stable operation from 0 deg to 150 deg F.

E. Sampling tubes shall be EMT tubing, 1/2-inch in diameter, length and support as required to extend across plenum or duct. Quantity and location of sampling tubes shall be as required for representative sampling. Plastic tubes will not be allowed.

2.28 TEMPERATURE CONTROL PANELS

A. Control panels shall be provided as required for mounting of system control devices as indicated

on the Drawings. Panel shall be sized as required to accommodate controls with hinged door, key lock. Panel shall be constructed of metal with metal mounting backplanes. All panels shall be supplied with the same key. All panels shall be NEMA rated and UL listed. Hoffman or equivalent.

2.29 CARBON DIOXIDE SENSOR

A. The carbon dioxide sensor shall be specifically designed to generate a linear 0-10 VDC or 4-20mA signal proportional to a 0-2000ppm CO2 level in the duct. The unit shall have an accuracy of +/-2% of full scale up to 1400ppm and a selectable auto-calibration mode. Sensor shall have a minimum of 5 year warranty. SENVA Sensors C02D or equivalent.

2.30 EQUIPMENT CONNECTIONS

A. Not Applicable.

2.31 ELECTRONIC LIQUID DIFFERENTIAL PRESSURE SENSOR

A. Electronic differential pressure transmitter shall be designed to measure the differential liquid pressure as indicated on the Drawings or as required. Liquid connection shall be 1/4" NPT and the enclosure shall be NEMA 4 with 1/2" conduit knockouts. The output shall be a two wire 4-20 mA loop powered device with an input range has indicated in the Drawings but not more than twice the actual measure variable. The accuracy including linearity, hysteresis and repeatability shall be less than or equal to ± 0.25% of full scale. Setra Model C230 or equivalent.

2.32 INDOOR STATIC AIR PROBE

A. Indoor static air probes shall be provided for each indoor air pressure measurement location. They shall be flush mounted with a concealed connection. They shall be constructed of 10 gage aluminum with a 1/8" coupling for output signal connection. Air Monitor S.A.P. or equivalent.

2.33 BOILER REMOTE SHUTDOWN SWITCH

A. The emergency shutdown switch or circuit breaker must be sufficient to disconnect all power to the burner controls. It shall be constructed in a manner that safeguards it against tampering. The switch and installation shall comply with the National Electric Code, NFPA No. 70 and ASME CSD-1 CE-110.

2.34 ELECTRONIC HVAC LIQUID FLOWMETER

A. Insertion Electromagnetic Type

1. The flowmeter shall be of the insertion electromagnetic type which penetrates into the line. The flowmeter shall be furnished complete with a flow transmitter which supplies a

4-20 mA or 0-10 VDC signal for flow. Meter shall have an accuracy of no less than 1% of the actual reading over the range of the meter. Meter shall include all necessary equipment to allow the flow meter to be inserted or removed without draining the system. Flow meter shall be installed within the manufacturer's required straight pipe lengths for accuracy. If the location of the insertion meter cannot meet these requirements, then the Inline Electromagnetic Type meter shall be used. Flow meter shall be Onicon F-3500 or equivalent.

B. Inline Electromagnetic Type

1. The flowmeter shall be of the inline electromagnetic type which installs into the line. The flowmeter shall be furnished complete with a flow transmitter which supplies a 4-20 mA or 0-10 VDC signal for flow and remote digital display. Meter shall have an accuracy of no less than 1% of the actual reading over the range of the meter. Meter shall be 24 VAC powered. Meter shall be Meter shall include all necessary gaskets required for installation into the system. Flow meter shall be installed within the manufacturer's required straight pipe lengths for accuracy. Flow meter shall be Onicon F-3200 or equivalent.

2.35 DOMESTIC WATER SUB-METER

A. The domestic water/irrigation flow meters shall include a supply flow sensor/ transmitter, supply pressure sensors/ transmitters, strainer, and wells as specified below. The meter shall have a local readout of flow. The meter and transmitters shall be utilize an input power of 24 VDC and shall provide a pulse output of totalized flow and a 4-20mA output signal for instantaneous flow and pressure. The meter and transmitters shall be suitable for operation in a mechanical room atmosphere in a 32 to 185 degrees F range. The meter and transmitters shall indicate the latest factory calibration and shall be tagged with abrass tag indicating service, building number, and calibration range. All transmitter enclosures shall be NEMA 4 with two 3/4" electrical hubs with plugs.

B. The flow sensor shall be an inline turbine type flow meter indicating flow in GPM. The maximum pressure drop across reduced-size meter assembly at maximum design flow shall be 1.8 psi. The flow sensor shall have an accuracy of +/- 1.5% of flow across the full range for the given pipe size. The meter shall operate over the temperature range of 40 to 100 degrees F and a pressure range of 0 to 100 psig. The meter housing shall be cast bronze with all internal pieces made of durable material such as thermoplastic or stainless steel. All bearings shall be self-lubricating. The transmitter shall have both an instantaneous flow and totalized flow output. A local totalization display shall be provided indicating instantaneous flow in GPM and totalized flow in gallons. The flow sensor shall be furnished with a strainer on the utility side of the meter. The strainer shall be provided so as to provide ease of maintenance. Flow sensor and transmitter shall be Turbo Badger Meter or prior approved equivalent.

2.36 GAS SUB-METER

A. The flow meter shall be hand-insertable up to 250 psi. Materials of construction for wetted metal components shall be 316 SS. The flow meter shall provide SFPM flow readings from a pair of encapsulated platinum sensors and shall not require additional temperature or pressure compensation. In addition, the meter shall continuously display information that can be used to

validate the calibration of the meter. Each flow meter shall be individually wet-calibrated against a standard that is directly traceable to NIST*. A certificate of calibration shall be provided with each flow meter. Provide flow meter assembly complete with all installation hardware necessary to enable insertion and removal of the meter without system shutdown.

B. Accuracy shall be within ± 1% of rate from 500-7000 SFPM and ± 2% of rate from 100-500 SFPM. Overall turndown shall exceed 1000:1. Output signals shall consist of the following: (1) analog 4-20mA output and (1) scalable pulse output for totalization. The meter shall be equipped with an integrally mounted graphical display that may be optionally remote mounted up to 1000 ft from the sensor. Each flow meter shall be covered by the manufacturer's two-year warranty. Provide an ONICON Model F-5500 Insertion Thermal Mass Flow Meter or equivalent. Meter shall be rated for outdoor application.

PART 3 - EXECUTION

3.1 GENERAL

A. All devices, conduit, wiring, etc., shall be installed in a neat professional manner by skilled persons.

1. The installation of all aspects of the system shall comply with all applicable codes and regulations and with Division 26 Specifications.
2. The installation of all materials shall be in accordance with the published manufacturer's recommendations without exception. If for some reason a particular component cannot be installed in compliance with these recommendations, the Contractor shall advise the Engineer of the situation.
3. Where miscellaneous materials are required to complete an installation, i.e., isolation valves for pressure switches, wall switches for an exhaust fan control circuit, etc.; the materials shall be supplied as defined in the relevant Section of these Specifications. For example, Section 23 0523 specifies valve requirements, and Division 26 specifies electrical products and requirements.
4. Coordinate with other trades where installation of a particular component requires other trades to be involved. Installation coordination includes location the correct placement of thermowells, flow switches, dampers, control valves, control power circuits, etc. Care must be exercised to identify locations that meet the requirements of the manufacturer including upstream and downstream distances, pressures, temperatures, etc.
5. Review the contract documents prior to installation. If the drawings show any instrumentation to be installed in a location where the system would not function properly (e.g., a temperature transmitter or thermostat located in a space not served by the terminal unit that transmitter controls) then submit an RFI with a sketch showing where the Contractor recommends the instrument be installed. Do not install instrumentation in locations where the system will not function properly.
6. All field devices shall be labeled with 1" x 3" phenolic labels. Labels shall include the point name and device name. Labels for EMS controllers shall indicate the breaker and panel number of the power source. Labels shall be glued, attached with screws, or copper wire in the case of valves and actuators.
7. On each terminal unit and fan control unit provide an adhesive film label showing the unit identification of the device as it appears on the construction drawings. The label shall be approximately three inches high by five inches wide, with the identification

characters approximately one inch high. The characters shall be printed in black on an orange background. The label shall be placed on the unit at a location easily observable by maintenance personnel.

3.2 PRIMARY OPERATORS STATIONS

A. The new primary operator workstation[s] hardware and software shall be installed at a location coordinated with the Owner or as indicated on the Drawings.

B. User Access

1. The Owner shall be interviewed and all desired passwords and password levels shall be installed at all workstations.

C. Reports

1. The Owner shall be interviewed and all reports desired shall be completely configured including correct formatting, delivery frequency, etc.

D. Dynamic Color Graphic Displays

1. All color graphic slides shall be developed to the satisfaction of the Owner. The slides shall include all realtime point assignments, user interactive points, and realtime alarm information. At a minimum, the following graphic slides shall be developed:

   a. One site map shall be provided which allows the operator to connect to any or building available to the operator. This area map shall include all buildings connected to the system. This graphics shall visually reflect the architectural features of the appropriate building. Global point information including OSA temperature and humidity, current demand level, and building outside air dry bulb and dew point temperatures shall be displayed on this graphic as applicable to the job. A "pick" shall be provided for the operator to move to any specific building.
   b. A graphic shall be provided for each building floor plan. All temperature zones within the floor plan shall be reflected and the actual temperatures within the zones shall be displayed. This graphic shall be color coded to reflect green if a particular temperature zone on the floor plan is at the setpoint temperature, blue if a particular temperature zone on the floor plan is below the setpoint temperature, and red if a particular temperature zone on the floor plan is above the setpoint temperatures. "Pick" windows shall be provided on these graphics to permit the operator to view specific temperature zone graphics relative to the respective floor plan.
   c. A graphic shall be provided for each temperature zone of each floor. This graphic shall be a "Zoom" view of the selected temperature zone of the respective floor plan. All information displayed on the building floor plan relative to any particular temperature zone and all color coding of the temperature zone shall be the same as was provided for the floor plan graphics. "Pick" windows shall be provide on these graphics to permit the operator to view specific mechanical system graphics relative to the respective floor plan.
   d. Separate graphics shall be provided for all mechanical equipment serving the respective building or zone. This includes all central station units, boiler plant, air

compressors, central plant, etc. Mechanical system graphics shall be displayed complete with all real time data relevant to the equipment being displayed including temperatures, flow rates, positions, etc.

2. Database Save/Restore/Backup

a. After all FMS controller software, operator workstation software, and graphic slides have been developed, two (2) complete backup sets of this software shall be delivered to the Architect for archiving.

3.3 FMS CONTROLLERS

A. General

1. All FMS controllers shall be installed in accordance with manufacturer's instructions. Power shall be provided to each FMS controller in accordance with Division 26 and all applicable codes.
2. All FMS controllers shall be installed in an enclosure that provides protection from the environment and is adequately ventilated to protect against excessive temperature exposure.

B. Input/Output

1. All points shown on the control diagrams or required to meet the Sequence of Operation shall be connected to the respective FMS controller in accordance with the manufacturer's instructions. Each point shall be checked for voltage, short circuit, etc., prior to termination to the FMS controller to prevent potential damage to the controller.

C. Software Requirements

1. General

a. All sequences of operation listed on the Drawings are to be implemented as they relate to the points shown on the Drawings. Any additional points required to meet the sequence of operation shall be provided whether indicated on the Drawings or not. In addition to the sequences of operation indicated on the Drawings, the following general sequences shall be implemented.

2. Optimal Start

a. Develop software to start all equipment based on the individual zone temperature, outside air temperature, heating/cooling capacity in degree Fahrenheit/hour of the equipment serving that zone and the previous optimal start time in establishing the optimal start time for the following day. The optimal start program shall work in conjunction with the scheduled start time to minimize energy consumption.
b. In no case shall the optimal start routine keep the AHU from running after the occupancy start time identified as the scheduled start time.
c. The AHUs shall run continuously until the scheduled stop time. No optimal stop program time shall be provided.

3. Run Time Totalization

    a. All digital input and output points shall be setup to accumulate run time information. Maximum run time limits shall be defined and shall automatically issue a printed message as defined by the Owner.

4. Alarms

    a. All analog input points shall have upper and lower limits established and alarms shall be generated in the event these limits are exceeded. The Contractor shall define reasonable limits for these alarm points. Digital inputs shall be compared to the associated digital outputs (fan start/stop and status) and alarms shall be issued if the commanded position is inconsistent with the actual condition, after a start delay timer. All alarms shall be directed to the primary operator workstations and shall be archived on the hard drives.

5. Minimum Runtimes

    a. All digital output points shall have a minimum runtime of five (5) minutes to prevent accidental short cycling.

6. Staggered Starts

    a. All digital outputs shall have staggered start times of at least 30 seconds to minimize demand spikes.

7. Trend Analysis (DDC Controller and all attached TCUs and ASCs)

    a. An order to verify and document satisfactory system operation, at a minimum, all trend logs defined in Appendix A shall be developed and implemented. As work of this Section, all control loops, inter-start delays, minimum and maximum run times, etc., shall be tuned to meet the constraints listed in Appendix A.
    b. All analog and digital trend logs shall be printed in text form with a graph of the corresponding trend data attached as the cover to the text trend data.
    c. All trend graphs shall be printed, maximized in landscape form, on one 8.5" x 11" sheet of paper. Graphs requiring the display of more points than can be reasonable displayed on one graph may be graphed on separate sheet, however, the time stamps of each graph must match exactly so that data from multiple graphs may be compared.
    d. Each analog graph shall include an "x" time/date axis scale and one or two "y" axis scales as required to adequately display the trend data. Each digital trend may be of any style and developed such that overlapping digital sequences are obvious to the viewer. Each axis shall be labeled and scaled. Axis scaling shall be set to clearly show the desired control response and required trend duration. A legend shall be provided clearly defining each trend line. Graphs may be color or black and white, however, black and white graphs must use patterns making the information clearly understandable. The time and date of displayed data shall be provided on both the text trend log printout and the graph printout. Examples of the minimum level of detail that will be required for all trend graphs are included in Appendix B of this Section.
    e. If trend logs are printed and graphed using cryptic systems point names, a legend

shall be provided with each trend to make the translation of the trended points easily understood.

f. All required trends, graphs, and completed point verification forms shall be compiled into a project closeout notebook(s) with tabs indicating the system being trended. For example, point verification forms for AHU-1, the supply air temperature control loop for AHU-1, the static pressure control loop for AHU-1, and the mixed air temperature control loop for AHU-1 shall be included under a tab labeled AHU-1. Zone trend data may be grouped under logical headings by AHU, floor, etc. A complete detailed index of all trend data and graphs shall be included in the front of the notebook(s). A page shall also be included in the front of the notebook identifying who performed which trend log.

g. The completed closeout notebook(s) shall be provided as part of the close out documentation required in Section 23 0500. Acceptance of the system will not be given until this requirement is met.

3.4 APPLICATION SPECIFIC CONTROLLERS

A. General

1. A maximum of one ASC shall be installed on each piece of equipment (i.e., blower coil unit, air handling unit, makeup unit, etc.,) and a maximum of one piece of equipment shall be connected to one ASC.
2. Power shall be provided to each ASC and installed in accordance with Division 26 and all applicable codes.
3. All FMS controllers shall be installed in an enclosure that provides protection from the environment and is adequately ventilated to protect against excessive temperature exposure.

B. Input/Output

1. All points listed on the Drawings or required to meet the sequence of operations shall be connected to the respective ASC in accordance with the manufacturer's instructions. Each point shall be checked for voltage, short circuit, etc., prior to termination to the FMS controller to prevent potential damage to the controller.

3.5 TERMINAL UNIT CONTROLLER

A. General

1. A maximum of one (1) TUC shall be installed on each piece of equipment (i.e., fan coil, VAV box, etc.,) and a maximum of one piece of equipment shall be connected to one (1) TUC.
2. Power shall be provided to each TUC and installed in accordance with Division 26 and all applicable codes.
3. All FMS controllers shall be installed in an enclosure that provides protection from the environment and is adequately ventilated to protect against excessive temperature exposure.

B. Input/Output

1. All points listed on the Drawings or required to meet the sequence of operations shall be connected to the respective TUC in accordance with the manufacturer's instructions. Each point shall be checked for voltage, short circuit, etc., prior to termination to the FMS controller to prevent potential damage to the controller.

3.6 OPERATOR INTERFACE PANELS

A. The operator interface panel shall be installed on or near the FMS control panel or as indicated on the Drawings. The panel shall be connected to the FMS network and programmed to allow the functionality described in Section 2.6 of this Specification.

B. The Owner shall be interviewed and all desired passwords and password levels shall be installed at the interface panel.

3.7 NETWORKING/COMMUNICATIONS

A. General

1. All LANs shall be installed in a manner recommended by the manufacturer, owner's representatives, based on the environment, communications speed requirements, and distance. All LAN media shall be installed in a manner that provides protection from physical damage and interference from RF or other electrical sources.

B. Primary Local Area Network (LAN)

1. The primary LAN shall be installed in accordance with all Division 26 communication specification requirements. The Contractor shall provide all conduit, wire, routers, hubs, etc., unless otherwise stated on the Drawings for a complete and operating FMS ETHERNET® communication network. All operator workstations and FMS controllers/routers shall be connected to the LAN.

C. FMS Controller Local Area Network (LAN)

1. The controller LAN shall be installed with materials and procedures that comply with the requirements of the FMS equipment manufacturer. In general, the conductors are to be a 22 gage, low capacitance, and twisted pair. All FMS controllers (if not connected to the primary LAN) and ACS controllers shall be connected to the LAN.

D. Sub-Controller Local Area Network (LAN)

1. The sub-controller LAN shall be installed with materials and procedures that comply with the requirements of the FMS equipment manufacturer. In general, the conductors are to be a 22 gage, low capacitance, twisted pair. All TU controllers shall be connected to the LAN.

3.8 DUCT STATIC PRESSURE STATION

A. Ensure that the direction of flow is observed when installing the probe to prevent measurement of total pressure. The connection between the duct and the flange shall be gasketed and secured with sheet metal screws to prevent any air leakage. Connections from the "HI" pressure port to the differential pressure transducer shall be 1/4" plastic tubing which shall not extend for more than ten feet. Pressure stations shall be installed 2/3 the distance down the duct of all major branch ducts or as indicated on the Drawings.

3.9 OUTSIDE AIR STATIC PRESSURE PROBE

A. Outside air static pressure probe must be installed and piped according to manufacturer's instructions to ensure accuracy of the static pressure reading and eliminate the effects of condensation in the sensing lines. Coordinate installation of probe with the necessary trades for proper sealing of all roof penetrations.

3.10 ELECTRONIC DIFFERENTIAL PRESSURE TRANSMITTER

A. All differential pressure transmitters shall be installed within ten feet of the pressure sensing point. The transmitters shall be installed in a NEMA I housing for interior conditioned spaces and in NEMA 3R housings for outside or unconditioned spaces. The transmitters and housings shall be rigidly supported to prevent vibration and shall never be mounted to ductwork or piping. Access to the transmitter shall be provided.

3.11 ELECTRONIC TEMPERATURE ELEMENT AND TRANSMITTER

A. Space temperature transmitters shall be installed 44" A.F.F. to the center of transmitter unless otherwise noted on the architectural drawings or specifications. Provide a locking metallic thermostat guard over room sensors in common areas.

B. All temperature sensors installed in liquid lines, tanks, etc., shall be installed in stainless steel thermowells. The thermowells shall be supplied to the mechanical contractor for installation under other Sections of the Specification. A thermo-conductive paste shall be applied between the sensing element and the thermowell.

C. Outdoor air temperature elements shall be installed in a location that is continuously shaded and not effected by heat generating equipment or equipment intakes or discharges. The element shall be installed under a sun shield and high enough to avoid damage from vandalism.

D. Duct point temperature elements shall be installed directly on ductwork and the connection between the duct and the flange shall be gasketed and secured with sheet metal screws to prevent any air leakage. Care must be taken to avoid direct contact between the temperature element and any heat transfer surface such as a coil.

E. Duct averaging elements shall be installed with the same requirements as for the temperature point elements; however; the averaging elements shall be extended across the entire duct area in a zigzag pattern. Special clips shall be used to secure the elements at turns to prevent chafing of the elements. Where the elements pass through the duct, plastic tubing or similar protection

shall be installed on the elements to prevent damage to the elements from vibration.

3.12 AIR FLOW STATION AND TRANSMITTER

A. Pitot Tube Air Flow Element and Transmitter

1. Ensure that the direction of flow is observed when installing the station in the ductwork. The station shall be installed in accordance with manufacturer's published up- and down-stream duct length requirements.
2. All connection points shall be secured. Connections from the "HI" and "LO" pressure ports to the air flow transmitter shall be 1/4-inch plastic tubing which shall not extend for more than ten feet.
3. The flow transmitter shall be wall mounted with the display at 60" A.F.F. The flow transmitter shall be completely setup to meet the actual field measurement conditions and output CFM. Provide 24 VAC power for transmitter.

B. Thermal Anemometer Air Flow Station

1. Ensure that the direction of flow is observed when installing the station in the ductwork. The station shall be installed in accordance with the manufacturer's published up- and down-stream duct length requirements. If a suitable location for the flow station cannot be achieved, the Contractor shall consult with the engineer and manufacturer with possible alternative locations.
2. All connection points shall be secured. Provide all power requirements for the unit and connect to the FMS.

3.13 ELECTRONIC HUMIDITY TRANSMITTER

A. Outdoor humidity transmitters shall be installed in a location not affected by equipments that might generate humidity or temperature effects. The transmitter shall be installed where direct moisture (rain) cannot contact the device.

B. Duct point humidity elements shall be installed directly on ductwork and the connection between the duct and the flange shall be gasketed and secured with sheet metal screws to prevent any air leakage. The sensing element shall be located at least ten feet downstream of any coil, humidifier, or dehumidified.

3.14 CURRENT TRANSDUCERS

A. Current transducers shall be installed on one hot leg of either single or three phase and after the local disconnect. The transducers shall be located in the motor starter housing or motor control center and secured to the structure using sheet metal screws.

3.15 CURRENT SENSING SWITCH

A. Current switches shall be installed in one leg of three phase circuits and the hot leg of single phase circuits and in all cases, after the local disconnect. The switches shall be adjusted to close

at approximately 10% of the attached loads full load amps.

3.16 AIR DIFFERENTIAL PRESSURE SWITCHES

A. Differential pressure switches shall be connected to pitot tube pickup probes pointing into the air stream on both sides of the process variable. Connection between the switch and the pitot tubes shall be 1/4" hard copper. The switches shall be adjusted to close at approximately 25% of the fans maximum speed or at the dirty filter pressure differential.

3.17 ELECTRIC LINE VOLTAGE THERMOSTAT

A. Where thermostats are to be mounted remotely from the controlled device, all conductors shall be installed in a metallic raceway and the thermostat shall be mounted on a junction box. Provide a locking metallic thermostat guard over the thermostat in common areas. Mount the thermostat 44" A.F.F. unless otherwise specified on plans.

3.18 ELECTRIC FLOW SWITCH

A. Flow switches shall be installed in a Thread-O-Let installed under Sections of the Specification. The paddle of the flow switch shall be selected and the spring adjustment shall be carefully set to provide good switching between flow and no flow conditions. Ensure that the flow direction of the device matches the actual flow direction.

3.19 ELECTRIC LOW LIMIT (FREEZESTAT)

A. Low limit thermostats shall be installed with the averaging element extended across the entire duct area in a zigzag pattern. Special clips shall be used to secure the element at turns to prevent chafing of the element. Where the element pass through the duct, plastic tubing or similar protection shall be installed on the element to prevent damage to the element from vibration. The thermostat setpoint shall be set as indicated and the circuit shall be tested to ensure actions as required.

3.20 CONTROL RELAYS

A. Control relays shall be field or panel mounted as indicated on the Drawings. If a relay is field mounted it will be installed in a NEMA I housing.

B. Control relays shall be installed in bases and the based mounted on a DIN rail. All accessories including end clips, jumpers, etc., shall be provided. All wiring shall be labeled. Multiple conductors shall be bundled and run by classification in plastic wireways. Relays shall be labeled as indicated in the shop drawings for ease in troubleshooting.

3.21 CONTROL TRANSFORMERS

A. Control transformers shall be field mounted using a plate to mount on the associated junction

box or panel using a foot-style mounting. Locations shall be as identified on the Drawings or as determined by field requirements. A phenolic label on each transformer shall identify the power source by breaker panel and circuit. Fusing of the primary and secondary sides and sizing shall be as defined by the NEC. Provide means of local disconnect for transformer to allow removal.

3.22 AUTOMATIC DAMPERS

A. All automatic control dampers shall be installed under Section 23 3000.

3.23 DAMPER ACTUATORS

A. Electronic Damper Actuators

1. Damper actuators shall be mounted on the damper jack shaft or shaft extender using a V-clamp. The actuator shall then be anchored to the ductwork housing the damper. All power requirements for the actuators shall be supplied under this Section of the Specification.

3.24 CONTROL VALVES

A. The valves shall be installed by the mechanical contractor under other Sections of the Specification.

3.25 CONTROL VALVE ACTUATORS

A. Electronic Valve Actuators

1. Valve actuators shall be supplied factory assembled with the respective control valve.

3.26 ELECTRICAL CONTROL POWER AND LOW VOLTAGE WIRING

A. Comply with all Division 26 installation requirements.

B. Install low voltage power wiring in conduit in the following locations regardless of local building code allowances otherwise.

1. Mechanical rooms.
2. Electrical rooms.
3. Vertical risers. (Exception: fire rated continuous closet like a telephone closet.)
4. Open areas where the wiring will be exposed to view or tampering.
5. Hard ceilings and walls.

C. Conceal conduit within finished shafts, ceilings and wall as required. Install exposed conduit parallel with or at right angles to the building walls.

D. Where Class 2 wires are in concealed and accessible locations including ceiling return air plenums, approved cables not in raceway may be used provided that:

1. Circuits meet NEC Class 2 (current-limited) requirements. (Low-voltage power circuits shall be sub-fused when required to meet Class 2 current-limit.)
2. All cables shall be UL listed for application; i.e., cables used in ceiling plenums shall be UL listed specifically for that purpose.
3. Class 2 wiring shall be run parallel along a surface or perpendicular to it, and NEATLY tied at ten foot intervals.

E. Do not install Class 2 wiring in conduit containing Class 1 wiring. Boxes and panels containing high voltage may not be used for low voltage wiring except for the purpose of interfacing the two (e.g., relays and transformers).

F. All wire-to-device connections shall be made at terminal blocks or terminal strip. All wire-to-wire connections shall be at a terminal block, or with a crimped connector. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.

G. Plug or cap all unused conduit openings and stubups. Do not use caulking compound.

H. Route all conduit to clear beams, plates, footings and structure members. Do not route conduit through column footings or grade beams.

I. Set conduits as follows:

1. Expanding silicone firestop material sealed watertight where conduit is run between floors and through walls of fireproof shaft.
2. Oakum and lead, sealed watertight penetration through outside foundation walls.

J. Cap open ends of conduits until conductors are installed.

K. Where conduit is attached to vibrating or rotating equipment, flexible metal conduit with a minimum length of 18" and maximum length of 36" shall be installed and anchored in such a manner that vibration and equipment noise will not be transmitted to the rigid conduit.

L. Where exposed to the elements or in damp or wet locations, waterproof flexible conduit shall be installed. Installation shall be as specified for flexible metal conduit.

M. Provide floor, wall, and ceiling plates for all conduits passing through walls, floors or ceilings. Use prime coated cast iron, split-ring type plates, except with polished chrome-plated finish in exposed finished spaces.

3.27 AIR PIPING

A. Copper tubing shall be supported no less than every 6' and run in a neat professional manner parallel with building lines. Tubing run loose shall be tied to building structures no less than every 6' and bundled where possible. Care shall be taken to avoid chafing at points of connection to the building.

3.28 SMOKE AND FIRE DETECTORS

A. Smoke detectors and the associated wiring shall be installed in accordance with Section 23 0549.

3.29 TEMPERATURE CONTROL PANELS

A. All tubing and wiring shall be clearly labeled with Brady-type marker labels and run to numbered terminal strips or tubing manifolds these wire, tube, and terminal numbers shall be shown on all control diagrams. Wires and tubes shall be labeled at all connection points.

B. All control devices shall be labeled with engraved phenolic tags showing device number and name, model number, setpoint, range, action, etc. Panel Face indicators shall be labeled with engraved phenolic tags identifying what is shown on indicator.

C. Hard tubing shall be brought into the panel using bulkhead fittings; tubing within the panel may be plastic.

D. Electronic digital indicators shall be provided where shown on the Drawings. Indicators shall be LED or LCD loop powered type and fully compatible with the associated transmitter and matched to the range of the transmitters. Indicators shall be flush mounted on the control panel door.

E. Terminal strips shall be provided in all control panels for the termination of all field wiring. An additional 25% but not more than 50 terminal strips shall be provided for future use. Terminal strips shall be rated for no less than 300 VAC, 1/4" in width, track mounted, and a slot provided for labeling strips. All terminals shall be labeled as shown on the as-built drawing. No more than two conductors shall be terminated on a single terminal.

F. Control transformers shall be provided where shown or where required to meet the sequence of operation. Control transformers shall be provided with a phenolic label identifying the source of power.

G. Control panel front mounted pilot lights shall be provided where shown on the Drawings or electrical ladder diagrams. Lights shall have replaceable bulbs and lenses and shall incorporate a "push-to-test" feature. Voltage rating of pilot light may be full load voltage or dropped across a line resistor. In no case may the voltage to pilot lights exceed 120 VAC.

H. Control panels shall have wire ways installed to group all wiring within a panel. Panels shall be manufactured in a professional manner to the satisfaction on the Owner and Engineer.

3.30 CARBON DIOXIDE SENSOR

A. Duct carbon dioxide shall be installed directly on ductwork and the connection between the duct and the flange shall be gasketed and secured with sheet metal screws to prevent any air leakage. The sensing element shall be located at least ten feet downstream of any coil, humidifier, or dehumidified.

B. Space carbon dioxide sensors shall be installed at the same height as room sensors.

3.31 EQUIPMENT CONNECTIONS

A. FMS Class II field wiring for all non-control device applications shall be installed under this Section of the Specification. This includes equipment such as VFDs, chillers, boilers, packaged air handling equipment, etc., that may have point types include status or alarm monitored from an equipment supplier Class C contact or analog control signals to equipment, etc.

3.32 ELECTRONIC LIQUID DIFFERENTIAL PRESSURE TRANSMITTER

A. All liquid differential pressure transmitters shall be installed within ten feet of the pressure sensing points. The transmitter shall be rigidly supported to prevent vibration and shall never be mounted to ductwork or piping. The piping for the sensing points shall include isolation valves such that the transmitter can be removed without having to shut down the liquid system. Access to the transmitter shall be provided.

3.33 INDOOR STATIC AIR PROBE

A. Indoor static air probes shall be mounted in the ceiling in locations indicated on the Drawings or as required.

3.34 BOILER REMOTE SHUTDOWN SWITCH

A. The manually operated remote shutdown switch or circuit breaker shall be located just outside the boiler room door and marked for easy identification. It should be installed in a location, which safeguards it against tampering. If the boiler room door is on the building exterior, the switch should be located just inside the door. If there is more than one door to the boiler room, there should be a switch located at each door.

3.35 ELECTRONIC HVAC LIQUID FLOWMETER

A. The flow meter/transmitter shall be installed according to the manufacturer's recommendations and tied into the FMS system.

3.36 DOMESTIC WATER SUB-METER

A. The sensors and transmitters shall be installed in accordance with the manufacturer’s installation requirements. All inline meters shall be installed with isolation valves on both sides. A by-pass is not required. The contractor shall connect all outputs from the transmitters and meter to the FMS per the requirements of these specifications. The contractor shall provide all necessary transformers to provide power for all transmitters and meters.

3.37 GAS SUB-METER

A. The sensors and transmitters shall be installed in accordance with the manufacturer's installation requirements. The contractor shall connect all outputs from the transmitters and meter to the FMS per the requirements of these specifications. The contractor shall provide all necessary transformers to provide power for all transmitters and meters.

END OF SECTION 23 0900

APPENDIX A

Verification Trend Log Development and Acceptance Requirements

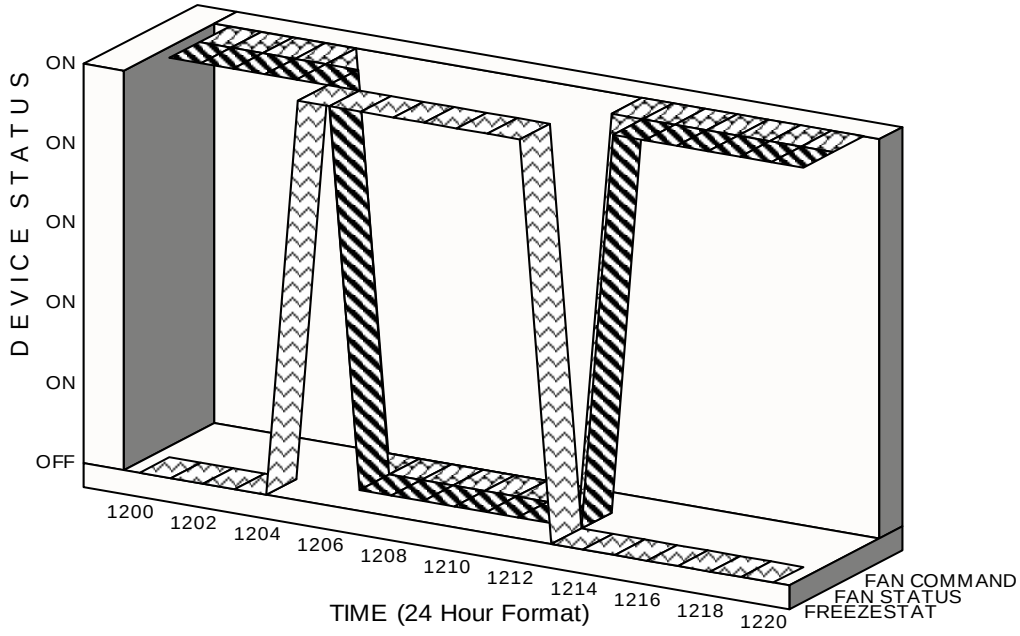
AHU-1 TREND LOG REQUIREMENTS			
Trend #1 (Supply Air Temperature Control)			
Trend Duration	Sample Interval	Trend Points	Required Response
60 minutes during occupied mode	1 minute	SA temperature SA temperature set point Hot water valve control signal Direct section control Indirect section control DX control	SA temperature ±0.5°F of SA temperature SP with hunting of no more than 5% of the control signal
Trend #2 (Supply Air Static Pressure Control)			
Trend Duration	Sample Interval	Trend Points	Required Response
60 minutes during occupied mode	1 minute	SA static pressure SA static pressure set point VFD control signal	SA pressure ±0.05°F of SA static pressure SP with hunting of no more than 5% of the control signal
Trend #3 (Mixed Air Temperature Control)			
Trend Duration	Sample Interval	Trend Points	Required Response
60 minutes during occupied mode	1 minute	MA temperature MA temperature set point Mixing damper control signal	MA temperature ±0.5°F of MA temperature SP with hunting of no more than 5% of the control signal
Trend #4 (Fan Safety Test)			
Trend Duration	Sample Interval	Trend Points	Required Test Sequence
N/A - Allow 2 minutes between test sequence events	1 minute	Fan commanded position Fan (VFD) status Freezestat Condition Supply air smoke detector Return air smoke detector MA damper signal	1) Fan stopped, safeties normal; 2) Fan commanded on, safeties normal; 3) Freezestat tripped; 4) Freezestat reset; 5) SA Smoke detector tripped; 6) SA smoke detector reset; 7) RA smoke detector tripped; 8) RA smoke detector reset;

VAV TERMINAL UNIT TREND LOG REQUIREMENTS			
Trend #1 (Space Temperature Control Range Test)			
Trend Duration	Sample Interval	Trend Points	Required Test Sequence
N/A - Allow full system response recovery between test sequences	1 minute	Space temperature Space temperature set point HW valve control signal Primary air control damper signal Primary air flowrate Primary air flowrate set point Primary air flowrate maximum Primary air flowrate minimum	1) Space temperature at or near set point; 2) Adjust space temperature set point 3.0°F below actual temperature; 3) Adjust space temperature set point 3.0°F above actual temperature; 4) Return space temperature set point to design condition;
Trend #2 (Space Temperature Control)			
Trend Duration	Sample Interval	Trend Points	Required Response
24 Hours – including transitions from unoccupied to occupied and occupied to unoccupied modes	10 minute	Space temperature Space temperature set point	Space temperature remains within ±0.5°F of space temperature set point with hunting of no more than 5% of the control signal for the hot water or primary air flow rates.

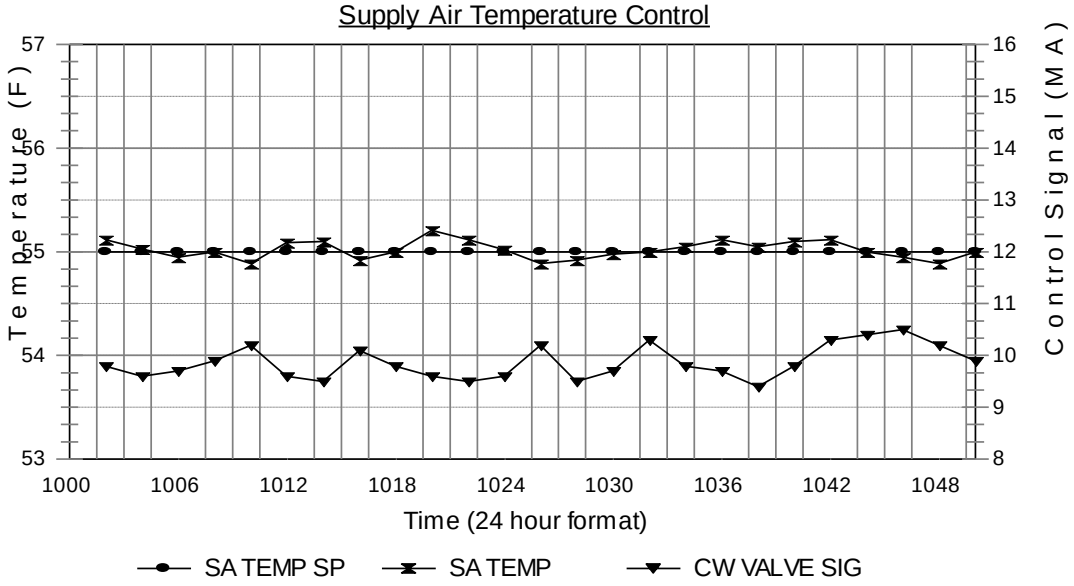
SECONDARY HOT WATER SYSTEM TREND LOG REQUIREMENTS			
Trend #1 (Differential Pressure Control)			
Trend Duration	Sample Interval	Trend Points	Required Response
60 minutes	1 minute	HW differential pressure HW differential pressure set point Control signal to VFD #1 Control signal to VFD #2	Differential pressure remains within ±1.0 PSID
Trend #2 (Differential Pressure Setpoint Control)			
Trend Duration	Sample Interval	Trend Points	Required Response
24 Hours – including transitions from unoccupied to occupied and occupied to unoccupied modes	10 minute	HW differential pressure HW differential pressure set point Maximum position of all HW valves Minimum position of all HW valves	Set point resets so that one or more of the hot water coil valves is between 90% and 100% open with hunting of the differential pressure set point less than 1.0 PSIG
Trend #2 (Pump Automatic Switchover Control Test)			
Trend Duration	Sample Interval	Trend Points	Required Test Sequence
N/A - Allow full system response recovery between test sequences	1 minute	HW differential pressure HW differential pressure set point HW pump #1 commanded position HW pump #1 status HW pump #1 control signal HW pump #2 commanded position HW pump #2 status HW pump #2 control signal	1) HW pump #1 on in lead position and in control; 2) Manually shut off the VFD serving HW pump #1; 3) Repeat steps #1 & #2 with HW pump #2 as the lead pump

APPENDIX B
Typical Trend Graph Requirements

AHU-1
Fan Safety Sequence Test



AHU-1
Supply Air Temperature Control



APPENDIX C
Typical Point Verification Form

POINT VERIFICATION FOR AHU-1						
Point Description	Software Point Name	Point Type	Date Tested	Results (Pass/Fail)	Contractor Initials(1)	Inspector Initials(2)
SA Temp Sensor	AH1SATMP	AI	11/1/99	Pass	RTC	ALM
SA Static Press	AH1SASTAT	AI	11/1/99	Pass	RTC	ALM
Fan S/S	AH1SAFSS	DO	10/14/99	Pass	RTC	ALM
Fan Status	AH1SAFST	DI	10/14/99	Pass	RTC	ALM
Freezestat(3)	AH1FZ	DI	10/13/99	Pass	RTC	ALM
CW valve control	AH1CWV	AO	10/14/99	Pass	RTC	ALM

(1) RTC is Robert T. Conbert of Acme Control Company, Inc.
(2) ALM is Albert L. Mackey, P.E. of Zebra Commissioning Company, Inc.
(3) Freezestat is also hard wired to stop fan in the hand or auto position. These interlocks were tested on the same day.

SECTION 23 2113 - HEATING HOT WATER SYSTEM AND EQUIPMENT

PART 1 - GENERAL

1.1 REQUIREMENTS

A. Conform with applicable provisions of the General Conditions, Supplementary Conditions and General Requirements.

1.2 RELATED SECTIONS

A. Section 23 0500 for Common Work Requirements for HVAC.

B. Section 23 0504 for Pipe and Pipe Fittings.

C. Section 23 0505 for Piping Specialties.

D. Section 23 0523 for Valves.

E. Section 23 0700 for HVAC Insulation.

F. Section 23 5216 Condensing Boilers

G. Section 23 0900, Facility Management System, for temperature control valves, meters and instrumentation.

H. Section 23 5216 – Condensing Boilers

I. See Division 26, Electrical.

PART 2 - PRODUCTS

2.1 PIPING

A. Hot water heating piping shall be black steel pipe A53 grade A or B, seamless ERW or BW, standard wall Schedule 40 through 10" diameter. Larger diameter pipe shall have wall thickness as follows:

Pipe Diameter, Inches	Wall Thickness, Inches
12" & larger	0.375
14" & Larger	0.500

B. Contractor may use Type L hard drawn copper tubing, ASTM B88 for hot water piping sizes 2" and smaller. Proper insulating fittings, as specified in Section 230504, shall be installed to prevent electrolytic action between steel and copper piping connections.

2.2 FITTINGS

A. Fittings for steel piping, 2" and smaller, shall be either screwed or welded. Screwed fittings shall be either Class 150, standard black malleable iron conforming to ANSI B16.3 or Class 125, standard black cast iron conforming to ANSI B16.4. Weld fittings shall be either standard weight steel butt-welding fittings conforming to ANSI B16.9 or forged steel socket-welding fittings, 2000 pound Schedule 40 conforming to ANSI B16.11.

B. Fittings for steel piping, 2-1/2" and larger shall be either standard weight steel butt-welding fittings, conforming to ANSI B16.9.

C. Fittings for copper piping shall be wrought copper conforming to ANSI B16.22, with 95-5 solder joints, as specified in Section 23 0504.

2.3 FLANGES

A. Flanges for steel piping system shall be forged steel, weld neck or slip-on, 1/16" raised face Class 150 flanges conforming to ANSI B16.5.

B. Flange connections for valves and equipment shall match the rating and drilling of the valves and equipment furnished.

C. Where specifically required by the application, black cast iron Class 125, standard threaded plain face companion flanges may be utilized for flanged connections in threaded piping systems.

D. Gaskets shall be 1/16" thick ring type or full face non-asbestos material suitable for the temperatures and pressure application,

E. Flange bolting shall be carbon steel machine bolts or studs and hex nuts, ASTM A307, Grade B.

2.4 VALVES

A. Valves other than automatic control valves are specified in Section 230523, HVAC Valves.

B. Automatic control valves shall be as specified in Section 230900, Facility Management System.

2.5 HOT WATER BOILER

A. Refer to Section 23 5216 – Condensing Boilers

2.6 PUMPS

A. Pumps shall be of the type and capacity listed in the Equipment Schedule and specified in Section 23 2123. Pumps shall be selected so that the motors will not overload under any operating condition. Furnish one spare mechanical seal of each size required in conjunction with the pumps furnished under this Contract. All pumps shall have drain pans with tapped pipe connections and 3/4" drain line extended to floor drain. Pumps shall be installed so that they may be removed without the removal of the associated piping.

2.7 HOT WATER UNIT HEATERS

A. Hot water unit heaters shall be propeller fan type, arrangement type as scheduled, adjustable discharge louvers for horizontal type, louver cone diffuser for projection type, hot water entering at 170 degrees F, and leaving at 150 degrees F. Furnish remote wall mounted electric 115-volt thermostat and safety fan guard. Trane, McQuay, or equivalent.

2.8 COILS

A. Hot water heating coils shall be as specified in Section 23 3000, and listed in the Mechanical Equipment Schedule.

2.9 EXPANSION TANK

A. Expansion tank shall be of the pressurized diaphragm type as specified in Section 23 0505 and listed on the Mechanical Equipment Schedule on the drawings.

2.10 WATER TREATMENT

A. Water treatment system, including shot type feeders shall be furnished by the Contractor.

B. Tanks shall be connected to the supply and return mains by means of 3/4" pipe with valves in each connection and with a 3/8" test cock on the supply connection. Tanks shall be wall or floor mounted on steel support adjacent to system pumps. The Contractor shall provide complete installation of water treatment equipment as shown on the drawings and as required by the Water Treatment Agency.

C. Chemicals as required for the system startup, operational testing and commissioning shall be provided by the Water Treatment Agency in sufficient quantities to maintain the level of chemical concentration recommended by the Water Treatment Agency and shall be included in the contract price. The exact type of chemical treatment compounds shall be determined by the Water Treatment Agency and approved by the Owner's Representative.

D. As a part of the contract price, the Contractor shall provide a one (1) year water treatment service contract by the Water Treatment Agency. Service contract shall include onsite testing on not less than a monthly basis and all required chemicals during the one (1) year project warranty period.

E. After system acceptance by the Owner, the continuing water treatment will be the Owner's responsibility.

2.11 FLOW MEASURING STATIONS

A. Furnish and install water flow measuring station and automatic flow control valves where shown on the drawings and as specified in Section 23 0505.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Piping installation shall conform to the requirements of Section 23 0500, Common Work Requirements for HVAC, Section 23 0504, Pipe and Pipe Fittings. Installation of specialties shall conform to the requirements of Section 23 0505, Piping Specialties.

3.2 CLEANING AND FLUSHING PIPING SYSTEMS

A. New heating water piping systems installed under this Contract shall be chemically cleaned of oils, greases, dirt and mill scale. The new piping system shall be inspected by the Owner's approved Water Treatment Agency to determine the appropriate cleanout procedures and recommended cleaning chemical materials.

B. Cleaning shall be performed in strict accordance with the chemical treatment agency and manufacturer's recommendations, and shall generally consist of the following:

1. Fill, flush, and drain piping systems with water to remove loose dirt and debris from the system.
2. Refill piping system with cleaning compounds, diluted to recommended concentrations and circulate for required time period.
3. Drain and flush system.
4. Neutralize using caustic and soda ash as required when cleaning with acid compounds.
5. Drain and inspect system and repeat cleaning if necessary.

C. In conjunction with piping system cleaning, clean and inspect all strainers and suction diffusers. Remove, bypass, or otherwise protect as necessary all piping system components which may be damaged due to chemical cleaning, including filters, instrumentation gauges, flow meters, etc.

D. After completion of chemical cleaning and flushing, the piping system shall be immediately refilled and maintained with treated water. Under no circumstances shall cleaned piping be allowed to sit empty or filled with untreated water.

3.3 TESTS

A. All piping shall be proven tight at a hydrostatic pressure of 150% of the system design operating pressure, but not less than 125 PSI. The system shall show no loss in pressure or indication of leakage at any joint or connection for a period of one (1) hour.

END OF SECTION 23 2113

SECTION 23 2123 - PUMPS

PART 1 - GENERAL

1.1 SCOPE OF SERVICES

A. Supply pumps as specified herein, including freight to job site. Coordinate with Contractor for delivery and proper installation. Align pumps, instruct Owner's operating personnel in proper operation and maintenance, and provide two sets of O&M Manuals.

1.2 WARRANTY

A. Provide parts and labor warranty for 18 months from shipment, 12 months from beneficial use. Warranty service must be guaranteed within four hours of notice, 24 hours per day, and 365 days per year.

1.3 SUBMITTALS

A. Five sets within one week after award: Full shop drawings for pumps and motors including assembly drawings; materials of construction; seal; motor HP, insulation, manufacturer, and full load motor efficiency; coupling; pump curve; and NPSH required.

PART 2 - PRODUCTS

2.1 PUMPS

A. General:

1. Factory assembled packaged pump and motor of bronze-fitted, cast iron construction, single-state, suitable for scheduled conditions of service. Entire assembly shall be finished with a suitable coating for long-term corrosion resistance.
2. General: Pump and motor mounted on steel or cast iron baseplate suitable for grouting in place, with raised lip drip pan and tapped drain connection. Coordinate rotation with piping and equipment layout.
3. Pump and motor capacities and efficiencies: Pump capacities shall be minimum as scheduled, and suitable for parallel operation. Motors shall not exceed HP listed. Unit shall operate over the entire pump curve without exceeding the motor nameplate rating. Supplier may deviate from the pump and motor efficiencies listed as long as the total electric power required to drive all pumps does not exceed the total power per the schedules, and as long as no motors change in size.
4. Pump characteristics: Curve shall rise continuously from maximum capacity to shutoff, operation at or near peak efficiency, capable of operating over entire flow range listed at full speed without exceeding breakoff point or exceeding manufacturer's recommendations. Impeller diameter shall not exceed manufacturer's minimum published diameter plus 90 percent of the difference between published maximum and

minimum impeller diameters.

5. Casing: close grain cast iron, 175 psig rated, with 125 psi ASA flanges, plugged drain and vent connections, and replaceable bronze wearing rings.
6. Impeller: Centrifugal type, total enclosed, non-overloading, one-piece bronze impeller, with entire rotating assembly statically, dynamically and hydraulically balanced.
7. Shaft: Carbon steel, minimum AISI C1045.
8. Motor: Squirrel cage induction type, 1.15 service factor, Class B insulation, premium efficiency per IEEE Standard 112, Test Method B, 460/3/60, non-overlooking and suitable for continuous operation at any point along the pump curve.
9. Bearings: Grease lubricated, moisture and dust resistant housing, minimum 20,000 hour B-10 life (100,000 hour average life) under scheduled conditions of service.
10. Coupling: Flexible type with removable guard, similar to Waldon, Thomas, Falk, Fast or Woods.

B. Horizontal Split Case Type: Double suction type, ODP motor, and 316 stainless steel shaft sleeve.

1. Mechanical seals: Single, unbalanced, inside mounted, end face rubber bellows type with stainless steel spring, brass or stainless steel seal heads, carbon-graphite rotating washer, and renewable tungsten-carbide stationery seat, similar to John Crane Type 1. Supply one spare seal of each size. Aurora Type 410.

C. End Suction Type:

1. Aluminum-bronze shaft sleeve, mechanical seal with brass and buna-carbon-ceramic seal, and bronze casing wearing ring. Suitable for pumping water at 200°F. Aurora Type 340.

D. In-Line Recirculating

1. Cast iron body, bronze fitted with mechanical seal. Bell & Gossett, Taco, ITT or Grunfos.

2.2 APPROVED MANUFACTURERS

Bell & Gossett
Aurora
Peerless
Armstrong
Groundfos
Weinman
Taco

PART 3 - EXECUTION

3.1 GENERAL

A. Coordinate rotation with drawings.

B. Prior to shipment clean flanges and exposed machined metal surfaces and treat with anti-corrosion compound. Protect flanges, pipe openings, and nozzles with wooden flange covers or with screwed-in plugs.

C. Provide pump foundations as indicated on drawings. Install pumps on foundations. Affix to base using either anchor bolts or expansion anchors.

D. Provide piping, valves, strainers, and instrumentation as indicated.

E. Align pumps per manufacturer's recommendations, but not less than within 0.002 inches. Grout pumps into place after alignment using non-shrink grout.

F. For pumps with variable speed drives provide a technician to set up drive as specified herein. Demonstrate proper system operation.

G. Supplier shall submit a written report stating that pumps are properly installed, aligned and operating.

H. Provide minimum two 2-hour training sessions for Operating Personnel.

END OF SECTION 23 2123

SECTION 23 2313 - REFRIGERANT PIPING SYSTEM AND EQUIPMENT

PART 1 - GENERAL

1.1 REQUIREMENTS

A. Conform to the applicable provisions of the General Conditions, the Supplemental General Conditions and the General Requirements.

1.2 RELATED SECTIONS

A. Section 23 0500, Common Work Requirements for HVAC.

B. Section 23 0504, Pipe and Pipe Fittings.

C. Section 23 0505, Piping Specialties.

D. Section 23 0523, Valves.

E. Section 23 0700, HVAC Insulation.

F. Section 23 0900, Facility Management System**,** for temperature control valves, meters and instrumentation.

G. Division 26, Electrical.

H. Refrigerant piping, insulation, and accessories associated with medical equipment and kitchen equipment furnished under other sections of this specification shall be furnished and installed by the equipment sub-contractors and is not a part of Division 23.

1.2 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE Compliance:

1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - " Procedures," and Section 7 - "Construction and System Start-up."

C. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.

1.3 COORDINATION

A. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.4 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period.

1. Warranty Period:

a. For Compressor: Five (5) years from date of Substantial Completion.
b. For Parts: Five (5) years from date of Substantial Completion.
c. For Labor: Five (5) years from date of Substantial Completion.

1.5 QUALIFICATION PROCEDURES

A. The storage, handling, and transportation of all refrigerants, oils, lubricants, etc. shall be accomplished in strict compliance with all State, local, and Federal Regulations including all requirements set forth by the Environmental Protection Agency (EPA) for the safe handling of regulated refrigerants and materials. The Contractor shall utilize qualified and/or certified personnel and equipment as prescribed by these requirements. In no situation shall any refrigerant be discharged to the atmosphere.

PART 2 - PRODUCTS

2.1 INDOOR AND OUTDOOR UNITS – 3 TON AND SMALLER

A. Indoor Units shall be as specified on the Equipment Schedule on the drawings and Section 23 3000.

B. Air-conditioning and heat-pump indoor units shall be Daikin, Mitsubishi (or approved equal) split system with Variable Speed Inverter Compressor technology. The system shall consist of a wall or ceiling mounted (see plans) indoor section with wired, wall mounted controller and a horizontal discharge, single phase outdoor unit.

C. The units shall be tested by a Nationally Recognized Testing Laboratory (NRTL) and shall bear the ETL label.

D. All wiring shall be in accordance with the National Electrical Code (N.E.C.).

E. The units shall be rated in accordance with Air-conditioning Refrigeration Institute’s (ARI) Standard 210 and bear the ARI Certification label.

F. The units shall be manufactured in a facility registered to ISO 9001 and ISO 14001, which is a set of standards applying to environmental protection set by the International Standard

Organization (ISO).

G. A dry air holding charge shall be provided in the indoor section.

H. The outdoor unit shall be pre-charged with R-410a refrigerant for 150 feet of refrigerant tubing.

I. The electrical power of the unit shall be 208 volts or 230 volts, 1 phase, 60 hertz. The system shall be capable of satisfactory operation within voltage limits of 198 volts to 253 volts. The power to the indoor unit shall be supplied from the outdoor unit, using the Daikin Control system. For A-Control, a three (3) conductor AWG-14 wire with ground shall provide power feed and bi-directional control transmission between the outdoor and indoor units.

J. The control system shall consist of two (2) microprocessors, one on each indoor and outdoor unit. Field wiring shall run directly from the indoor unit interconnected by a single non-polar two-wire AWG-16 stranded cable to the wall mounted controller with no splices. The control system between the outdoor unit and indoor unit shall be supplied from the outdoor unit using the Daikin Control system. The system shall be capable of automatic restart when power is restored and after power interruption. The system shall have self-diagnostics ability, including total hours of compressor run time. Diagnostic codes for indoor and outdoor units shall be displayed on the wired controller panel. The microprocessor located in the indoor unit shall have the capability of monitoring return air temperature and indoor coil temperature, receiving and processing commands from the wired controller, providing emergency operation and controlling the outdoor unit.

K. The indoor unit shall be connected to a wall mounted wired controller to perform input functions necessary to operate the system. The wired controller shall have a large multi-language DOT liquid crystal display (LCD) presenting contents in English and Spanish. There shall be a built-in weekly timer with up to eight pattern settings per day. The controller shall consist of an On/Off button, Increase/Decrease Set Temperature buttons, a Heat/Auto/Cool/Dry/Fan mode selector, a Timer Menu button, a Timer On/Off button, Set Time buttons, a Fan Speed selector, a Vane Position selector, a Louver Swing button, a Ventilation button, a Test Run button, and a Check Mode button. The controller shall have a built-in temperature sensor. Temperature shall be displayed in either Fahrenheit (°F) or Celsius (°C). Temperature changes shall be by increments of 1°F (1°C) with a range of 67°F to 87°F (19°C to 30°C).

L. The wired controller shall display operating conditions such as set temperature, room temperature, pipe temperatures (i.e. liquid, discharge, indoor and outdoor), compressor operating conditions (including running current, frequency, input voltage, On/Off status and operating time), LEV opening pulses, sub cooling and discharge super heat.

M. Normal operation of the wired controller shall provide individual system control in which one wired controller and one indoor unit are installed in the same room. The controller shall have the capability of controlling up to a maximum of sixteen systems at a maximum developed control cable distance of 1,500 feet (500 meters).

N. The control voltage from the wired controller to the indoor unit shall be 12 volts, DC. The control signal between the indoor and outdoor unit shall be pulse signal 24 volts DC. Up to two wired controllers shall be able to be used to control one unit.

O. Control system shall control the continued operation of the air sweep louvers, as well as provide

On/Off and mode switching. The controller shall have the capability to provide sequential starting with up to fifty seconds delay.

P. Provide Hail Guards for outdoor condensing coils.

2.2 20 TON AND LARGER OUTDOOR AIR COOLED CONDENSER

A. Furnish and install air cooled condensers located as shown on the drawings. Air cooled condenser shall be of type and capacity as specified in the Mechanical Equipment Schedule on the drawings. All condensing units are factory assembled and wired. Unit frames are constructed of 14 gauge welded galvanized steel with 14 and 16 gauge galvanized steel panels and access doors. The unit surface is phosphatized and finished with an air-dry paint to withstand 500 hours of continuous salt spray solution in accordance with ASTM B117. Decorative louvered panels provide condenser coil protection.

B. Compressor - R-410A Scroll compressors have simple mechanical design with only three (3) major moving parts. Compressors shall be completely enclosed compression chamber with no leakage paths. The compressor is suction gas cooled, direct drive, 3600 RPM hermetic motors. The Scroll compressor includes a centrifugal oil pump, oil level sight glass, and an oil charging valve.

C. Refrigerant Management - Each compressor shall have crankcase heaters installed, properly sized to minimize the amount of liquid refrigerant present in the oil sump during off cycles. Additionally, the condensing unit shall have controls to initiate a refrigerant pump down cycle at system shut down on each refrigerant circuit. To be operational, the refrigerant pump down cycle requires a field-installed isolation solenoid valve on the liquid line near the evaporator.

D. Condenser Fan and Motors - R-410A Vertical discharge direct-drive fans are statically and dynamically balanced. Fan motors are three-phase with permanently lubricated ball bearings, built-in current and thermal overload protection.

E. Microchannel Condenser Coil -l R410A Condenser coils are dual circuit having an all Aluminum Microchannel design. The coils are burst tested and leak tested. Factory installed liquid line service valves are standard.

F. Provide Hail Guards for outdoor condensing coils.

G. Refrigerant Circuit - R410A Each unit has two independent refrigeration circuits with 3 compressors per circuit piped in parallel. Six step capacity control is accomplished through compressor cycling.

H. Standard Ambient Control - R410A Standard ambient control allows unit operation from 40 F to 115 F .

I. Roof curb – 24 inches tall with 2” spring isolators.

1. Prefabricated Vibration isolation curb to be manufactured of prime galvanized steel construction, 14 gauge, meeting ASTM A653/653M, with welded corners and with seams joined by continuous water and air tight welds. Vibration isolation curb shall be internally reinforced with bulkheads 48” on center and factory installed wood nailer. Top of all

Vibration isolation curb shall be level, with pitch built into curb when deck slopes. Vibration isolation curb shall be designed to provide a minimum of 90% isolation efficiency with 2" deflection. 9" continuous rubber cover around perimeter of Vibration isolation curb over spring isolators. Thybar Vibro-Curb III or equivalent.

J. Pressure Gauges - R410A Pressure gauges are mounted adjacent to compressors to monitor suction, discharge and differential oil pressure for each refrigerant circuit.

K. Service Valves - R410A. Provide isolation valves at each refrigerant piping connection in order to isolate compressors for servicing. This valve is a refrigerant shut off valve.

L. Provide Hot Gas Bypass refrigerant line from condensing unit to evaporator inlet.

M. Factory-Installed electrical power wire termination and combination starter/disconnect enclosure.

N. The disconnect shall be rated for adequate interrupting capacity (Short Circuit).

O. Manufacturers

1. Manufacturers: Manufacturer of the Air Cooled Condensing unit shall be the same as the manufacturer of the air-handling unit in 23 7313. Subject to compliance with requirements, provide products by one of the following:

a. York
b. Trane Company.

2.3 PIPING

A. Refrigerant piping materials and installation shall be in accordance with the best working and piping practices for Freon refrigerants. The Contractor shall install the refrigerant piping using Type "L" hard drawn copper tubing, Federal Specification WW-T-749, with silver solder joint. All piping shall be installed in a straight manner, free from traps, and shall be provided with plugged or capped ends, as it is erected, to prevent dirt from entering. The piping system shall be provided with gauges as required for the operation of the system. Refrigerant piping layout and routing shall be approved by manufacturer of the condensing unit and engineer of record prior to installation.

2.4 VALVES

A. Expansion valves shall be of the thermostatic type as manufactured by Alco, Sporlan, or equivalent, and shall be gas charged with capillary tube, external superheat adjustment and external equalizing connection. The expansion valves at each apparatus shall be protected by a strainer in the refrigerant liquid line to that group. The strainer shall be as manufactured by the Henry Valve Company, or equivalent, not less than line size and provided with shut-off valves before and after, and furnished with the packaged reciprocating unit.

B. Solenoid valves shall be suitable for the system in which they are used and shall be designed specifically for use with Freon refrigerants. Solenoid valves shall be furnished with the

packaged reciprocating unit.

C. Refrigerant line valves shall be packless type or packed type with gas tight cap seal with wheel, globe, angle, or "T" needle type, with hard metal seats and shoulders on stems to permit packing stuffing boxes while open under pressure, or sealed diaphragm type.

2.5 DRYER

A. In each liquid line, install a suitable silica gel filter and dryer. Dryer shall be furnished with the chiller.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Piping installation shall conform to the requirements of Section 23 0500, Common Requirements for HVAC, and Section 23 0504, Pipe and Pipe Fittings.

B. Install units level and plumb.

C. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

D. Install roof-mounted, compressor-condenser components on roof skids.

E. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

3.2 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Tests and Inspections:

E. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

F. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

G. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

H. Remove and replace malfunctioning units and retest as specified above.

I. Prepare test and inspection reports.

3.3 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Complete installation and startup checks according to manufacturer's written instructions.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain units.

3.5 INSTALLATION

A. Piping installation shall conform to the requirements of Section 23 0500, Common Requirements for HVAC, and Section 23 0504, Pipe and Pipe Fittings.

3.6 TESTING OF REFRIGERANT PIPING SYSTEM

A. After the installation of the refrigerant piping system has been completed, all piping shall be tested and proven tight for a period of twenty four (24) hours at a pressure of 150 lbs. per square inch using dry nitrogen.

3.7 EVACUATION AND CHARGING

A. Upon completion of the piping pressure test, the refrigerant circuit shall be evacuated to 500 microns using a closed tube manometer and a high vacuum pump (using an electronic vacuum gauge that reads in microns) to ensure tightness of the piping and to remove air and moisture from the piping system. Upon completion of evacuation and acceptance of the system tightness, the vacuum shall be broken by the introduction of the refrigerant.

3.8 REFRIGERANT AND LUBRICATING OIL

A. Contractor shall furnish and install all of the refrigerant required to develop the system to its full rating, and in addition to the initial charge, the Contractor shall be required to provide all refrigerant required for the proper operation of the refrigeration apparatus during the first season's operation. Contractor shall guarantee that the loss of refrigerant for a season's operation shall not exceed 10% of the full charge of the system and he shall furnish any refrigerant required above this amount. This guarantee shall remain in effect until such time as the Contractor shall demonstrate this performance for one full year's operation. The Contractor

shall be required to provide the initial charge of lubricating oil for all refrigeration apparatus and related equipment, and shall furnish a chart listing the type of oil and a schedule for maintenance that should be used with the various equipment.

3.9 PRESSURE RELIEF DEVICES

A. Refrigerant pressure relief devices and fusible plugs shall be installed with piping to a safe location in accordance with ANSI/ASHRAE Standard 15-1994. Discharge shall be to atmosphere at a location not less than 15 feet above the adjoining ground level and not less than 20 feet from any window, ventilation opening, or exit from any building. Discharge line sizing shall conform to ANSI/ASHRAE Standard 15-1994.

B. Each discharge pipe shall be equipped with a drip leg capable of holding 1 gallon of liquid. The drip leg shall include a manual drain valve.

END OF SECTION 23 2313

SECTION 23 3000 - AIR TEMPERING SYSTEM AND EQUIPMENT

PART 1 - GENERAL

1.1 REQUIREMENTS

A. Provide all products, labor and services necessary to construct and demonstrate proper functionality of the HVAC and exhaust systems indicated on the drawings and specified herein.

B. Conform with applicable provisions of the General Conditions, the Supplemental General Conditions and General Requirements.

C. See Sections 23 0500, 23 0548, 23 0549, 23 0593, 23 0700, and 23 0900 for additional requirements.

D. Comply with the Equipment General Requirements in Spec Section 23 0500.

1.2 SCOPE

A. Install control dampers supplied under Section 23 0900. Adjust dampers for smooth operation.

B. Equipment provided by others: Provide ductwork to serve equipment provided by others, including fume hoods, etc, where that equipment requires ducted supply or exhaust.

1.3 SUBMITTALS

A. Submit the following for review and approval:

1. All equipment shown on the equipment schedule and elsewhere on the drawings. Submit evidence or certification that equipment complies with ASHRAE Std. 90.1.
2. Ductwork construction standards, sheet metal, plenums, ductwork accessories, etc.
3. Flues and vents: Materials of construction and accessories. For vents with horizontal offsets or expansion joints, submit layout for review.
4. Dampers for fire and smoke control: For each type of damper proposed, submit manufacturer's literature demonstrating compliance with all aspects of the specifications and drawings. Submit manufacturer's installation instructions.
5. Air Filters and Filter Gauges
6. Grilles, Registers & Diffusers: Configuration, materials of construction, finish, mounting details, and performance data including throw, static-pressure drop, and noise ratings. Submit for type only, but supplier shall check and verify that the indicated diffuser type and sizing are appropriate for each area. Advise of any concerns in any areas.
7. Terminal Units:

    a. Submit the following for each type of unit: Unit construction, materials, and wiring diagrams.
    b. Submit the following for each size unit: Dimensional data, recommended flow

ranges, and performance data (pressure drop and sound data) at maximum flow.

c. Submit a schedule showing the following for each terminal unit indicated on the drawings: Tag number, max & min CFM, size, pressure drop, and heating system performance.

8. Layouts of systems covered by this section of the specifications. Layouts shall be at a scale appropriate for the areas shown. Include large scale sections as appropriate.

1.4 QUALITY ASSURANCE

A. Comply with the following codes & standards:

1. UMC 2006 Chapter 6 – Duct Systems
2. UMC 2006 Standard 6-2, Standard for Metal Ducts
3. SMACNA 2005 HVAC Duct Construction Standards – Metal and Flexible, including Addendums
4. SMACNA Round Industrial Duct Construction Standards – 1999
5. SMACNA Rectangular Industrial Duct Construction Standards – 2004
6. NFPA-90A-2002 - Standard for the Installation of Air-Conditioning and Ventilating Systems

B. Component Characteristics

1. All components within ducts and plenums shall be non-combustible or shall have a flame spread less than 25 and smoke developed less than 50 when tested as a composite product per NFPA 255, ASTM E84, or UL 723, except where specifically permitted by the UMC and noted in the drawings or specs.

1.5 SOUND LEVELS

A. Sound levels attributable to mechanical equipment are designed to result in sound levels of NC 40 for offices, conference rooms, and NC 35 for library, classrooms, etc., measured within the rooms. Mechanical equipment that has been substituted for the specified equipment shall perform within the specified equipment sound limitations, or will be replaced or adjusted as required. Sound levels attributable to duct vibration that result in noticeable noise or vibration to duct hangers, lighting fixtures, ceiling tees or diffusers shall be re-supported or adjusted until the disturbing noise is brought within acceptable limits.

1.6 DIMENSIONS

A. Compare all drawings and verify all dimensions both on the drawings and in the field before laying-out, cutting, and fabricating the work.

B. Refer to Section 23 0500, Common Work Requirements for HVAC, for coordination drawing requirements.

PART 2 - PRODUCTS

2.1 DUCTWORK AND PLENUMS

A. Materials: Construct all ducts, casings, plenums etc. from galvanized steel sheets except as indicated. Sheets shall be free of blisters, slivers, pits, and imperfectly galvanized spots. Reinforcing angles and bars, and duct support materials shall be same material as ductwork if exposed to the air stream, or galvanized steel if not exposed to the air stream.

1. Galvanized Steel: Per ASTM A653/A653M Standard Specification for Steel Sheet, Zinc-Coat (Galvanized) by the Hot Dip Process G90 coating designation.
2. Aluminum: Alloy 3003-H14
3. Stainless Steel: 340SS, provide No. 2B finish in exposed areas
4. Fiberglass Ductwork (Ductboard): Use only where specifically noted. Minimum 1-inch thick, 3 lb. density rigid fiberglass ductboard with glass fiber reinforced vapor barrier, UL Class 1, labeled on each board per UMC-06 Standard 6-5.

    a. Properties:
        1) Thermal conductivity for 1-inch thickness shall not exceed 0.22 Btuh/SF-F at 75 deg F
        2) Noise reduction coefficient of 0.80 on Mounting No. 6.
    b. Tape: 3-inch "Hardcast" mineral impregnated woven fiber tape with an actuator/adhesive applied in accordance with the manufacturer's directions, or thermlok heat sensitive tapes. Pressure sensitive tapes will not be accepted.
    c. Owens-Corning Fiberglass, Johns Manville, Certain-Teed or equivalent. Flexural rigidity (E.I.) average shall not be less than 475.

5. Polyvinyl Coated Galvanized Steel: Minimum 4 mil polyvinyl coating. Foremost Manufacturing Company, Southfield, Michigan. Model PCD 4 by 1 for exterior coating only, or Model PCD 4 by 4 for both interior and exterior coating.

B. Flexible Ducts: Factory fabricated, listed as a Class 1 Air Duct per UL 181 with aluminum foil interior liner, corrosion resistant helix mechanically locked to fabric to ensure dimensional stability, helix separated from air stream, R-5 fiberglass insulation, and metalized outer vapor barrier. Ducts shall be rated at 10-inch positive pressure, 5-inch negative pressure, 0.1 perm per ASTM E96, and -20 to +250ºF. Flexmaster Type 3M, Thermaflex M-KC, OAE.

C. Ductwork Accessories

1. Sealers: Water based, for use on galvanized steel and with the other materials specified herein, suitable for use at -20 to +200ºF and duct pressures to 10 inches wg, dry to the touch within 12 hours, sufficiently flexible to pass a 0.25-inch mandrel test, listed per UL-181A & 181B, and suitable for storage and application at 40–110ºF. Approved Manufacturers: Carlisle Coatings & Waterproofing “Hardcast,” Foster, RCD, AM Conservation Group, OAE.
2. Tapes: 4” woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal. Water, mold, and mildew resistant for indoor and outdoor service. Sealant shall be modified styrene acrylic.

2.2 SHEET METAL ACCESSORIES

A. Dampers: Factory fabricated, suitable for use with air at -20 to +240°F, galvanized steel housing and blades except as noted, rated for indicated pressures in either direction and performance rated per AMCA-500.

1. Shafts: Square or hexagonal steel, 3/8-inch or 1/2-inch, continuous through damper, mechanically fastened to damper blade, and extending through frame as required for actuator or standoff bracket and locking quadrant as required by table below.
2. Bearings: Provide for each side of each shaft, molded synthetic or stainless steel sleeve type.
3. Multi-blade dampers: Except as indicated, provide parallel-blade for 2-position applications and opposed blade for modulating applications. Provide jackshafts as required to drive large dampers.
4. Air pressure drop shall not exceed:

   a. Dampers rated at 1500 FPM: ____ in wg at 1500 FPM
   b. Dampers rated at 4000 FPM: ___ in. wg at 4000 FPM

5. The dampers described in this section are assigned Type Numbers D1 through D23. The following table summarizes key characteristics of each type of damper. Drawings and Part 3 – Execution, indicate which type of damper to use in each application.

Type	Shape	Blade	Max Size (inches)	Multiple Sections	Rated Velocity (FPM)	Rated Shutoff Press. (in. wg)	Seals	Leakage (CFM/SF @ 1 in. DP)	Notes	Ruskin Model
D1	Rect	Flat	36 x 12	No	1500	2.5	No	--	1	MD15
D1	Rect	3V	48 x 48	No	1500	2.5	No	--	1	MD15
D2	Rect	Flat	36 x 12	No	1500	2	No	--	1	MD25
D3	Rect	3V	48 x 48	Yes	1500	2	No	80	1	MD35
D4	Rect	3V	48 x 72	Yes	1500	2.5	No	40		CD35
D5	Rect	3V	48 x 72	Yes	1500	2.5	Yes	4		CD36
D6	Rect	Airfoil	60 x 72	Yes	4000	6	Yes	2	2	CD50
D7	Rect	Airfoil	60 x 72	Yes	4000	6	Yes	2		CD60
D20	Round	Flat	20	No	1500	2	No	40	1	MDSR25
D21	Round	Double	40	No	4000	10	Yes	4		CDR25
D22	Round	Double	24	No	4000	6	Yes	6		CDSR25
D23	Oval	Double	72 x 24	No	4000	10	Yes	4		CDO25

Note 1: Provide locking hand quadrant and 2-inch standoff bracket
Note 2: Aluminum Construction

B. Flexible Connectors: Except as noted flexible connectors shall be heavy fiberglass cloth; coated to be air tight, water tight, fire retardant; suitable for temperatures of -20 to +200° F; rated for 10 in. wg positive or negative; with tensile strength minimum 450 lb/inch in the warp and 340 lb/inch in the filling. Provide flexible connectors in 3-3-3 configuration, with 3-inch galvanized steel strip along each edge and 3-inches of flexible fabric in the center.

1. Standard Applications: Flame spread 20, smoke developed 40, Ventfabrics Ventglas OAE
2. Applications Exposed to Sun and Weather: Double coated with du Pont Hyphalon, Ventfabrics Ventlon OAE.
3. Applications from 200 – 500° F: Tensile Strength 285 lb/inch in the wrap and 185 lb/inch in the filling. Ventfabrics Ventsil OAE
4. Corrosive Applications: Teflon coated, Ventfabrics Ventel OAE.

C. Duct and Plenum Access Doors: Galvanized steel, gasketed. Size as required to properly inspect and service components located within the ductwork. Ruskin, Acudoor, Ductmate, OAE.

1. Rectangular ducts up to 2-inch positive or negative SP: Minimum 22 gauge frame and door thru 12-inch size, 20 gauge door for larger sizes, double gasketed (between door and frame, and between frame and duct) with cam locks, either hinged or removable. Ruskin ADH22, ADC22, ADHW22, or ADCW22, Ventfabrics, OAE
2. Round or Rectangular Ducts to 12-inch Positive Pressure: Removable oval sandwich style with gasketed inner door, insulated outer door, and large hand knobs. Ruskin ADR and ADF.
3. Ducts to 12-inch Negative Pressure: Ruskin ADHP-3.
4. Plenum Access Doors: Factory fabricated frame and door rated to 4-inch positive or 8-inch negative pressure. Provide mill finish and neoprene seals to limit leakage to less than 0.1 CFM/inch perimeter with door closed. Doors shall open against air pressure.

    a. Frame: Extruded aluminum with 1.5-inch flange and mitered corners
    b. Door: Extruded aluminum mitered frame, double wall 24-gauge galvanized steel panel with minimum R-5 insulation isolated from the air stream, full-length piano hinge and two heavy-duty latches similar to Ventlok 310.
    c. Approved Manufacturers: Ruskin GPAD or approved equal.

D. Turning Vanes:

1. Single wall: Per SMACNA HVAC Duct Construction Standards Figure 2-3 & 2-4.
2. Double wall: Airfoil shape with smoothly rounded entry nose and extended trailing edge, minimum 2” x 3” vane crossection, hot dipped galvanized steel, 26-gauge vanes, 24-gauge runner, each vane double pinned to each runner, field adjustable to required elbow aspect ratio. Performance shall not exceed the following for a 24 x 24 elbow at 2000 FPM average: Air pressure drop 0.105 in. wg; aound generated 54 dB re 10^-12 watts. Aero/Dyne Co. Model HEP, Airsan, Elgen, or equivalent.

E. Roof Curbs and Equipment Support Rails: Factory fabricated, minimum 14-inch high, galvanized steel, configured to account for roof pitch where pitch exceeds 1/4-inch/ft or where required by manufacturer of supported equipment. Coordinate with roofer and provide cant and step if needed to match roof construction.

1. Roof Curbs: 1.5-inch fiberglass insulation with nominal 2" x 2" wood nailer. Provide damper tray where a damper is indicated. Thycurb TC, Greenheck, OAE.
2. Equipment Support Rails: Nominal 2" x 4" wood nailer. Thycurb TEMS, Greenheck OAE

F. Louvers: 4-inch extruded 6063-T5 aluminum alloy frame and blades with flange, mill finish, and 1/2-inch galvanized steel bird screen.

1. Structural: Designed and furnished to carry wind load of not less than 20 psf. Intermediate mullions and supports if provided as part of louver, shall not be visible from the exterior.
2. Air Pressure Drop: Less than 0.20 in wg at 1000 FPM over free area (8.58 square feet), intake or exhaust per AMCA 500 based on 48 x 48 test sample.
3. Moisture Penetration: Less than 0.01 oz/sf over 15 minute test per AMCA-500 at 873 FPM intake over free area based on 48 x 48 test sample.
4. Ruskin ELF375DX OAE.

G. Acoustic Louvers

1. Ruskin ACL 1245, 12 inches deep, with 45 degree blade angle, 22 percent free area (48" x 48" typical unit with .15 inch w.g. maximum pressure drop, at 4277 cfm air flow). Frame and blade material shall be galvanized steel. Free field noise reduction shall be:

Band Frequency (Hz)	63	125	250	500	1000	2000	4000	8000
Reduction (db)	14	13	15	20	23	22	20	20

2. Provide bird-screen, steel channel frame, Ruskatherm blanket insulation, and perforated steel interior surface that covers insulation.

H. Thermometers: As specified in Section 23 0505.

I. Barometric Pressure Balance Dampers: Air Balance, Inc. units with adjustable counter weight, aluminum air foil design blades, nylon bearings. Match frame assembly to wall or duct.

2.3 FLUES AND VENTS FOR FUEL-FIRED EQUIPMENT

A. General: Factory-built metallic vent system, UL Listed components. Each component shall bear indication of its UL listing.

1. Heat Resistant Paint: Glidden, Metallite OAE.
2. Approved Vent Manufacturers: Metal Fab, Metalbestos, Schebler, Ampco, OAE.

B. Type B Vent: Listed per UL 441 for use with UL Listed Category I (gas or propane fired, negative pressure, non-condensing) appliances to 530° F, round or flat oval as indicated, double wall with aluminum alloy inner wall, galvanized steel outer wall, both walls hemmed to eliminate sharp edges, minimum 1/4-inch air space for sizes 6-inches and smaller and minimum 1/2-inch air space for sizes 7-inches and larger, with guides to maintain air space. Provide UL Listed vent cap. Metal Fab Type M.

1. Barometric Draft Regulator: UL Listed, double acting type.

C. Type III Vent: For use with Category III appliances or other positive pressure, non-condensing appliances including oil-fired or solid-fuel equipment not exceeding 1200° F exhaust temperature. Listed per UL-103 for use with gas, liquid or solid fuels per NFPA-211 which produce gases up to 1400° F continuously and 1800°F intermittently. Double wall with spacers

to maintain alignment, rated for 10-inch clearance to combustibles, 4-inch clearance to noncombustibles, and zero clearance to fire-rated or non-combustible chase.

1. Inner Pipe: Connected with V-bands of same material as inner pipe, and sealed with silicone sealant appropriate for the exhaust gas temperature. Pressure tight to 60 inches water.
2. Outer Pipe: Seal with V-band of same material as outer pipe. Provide silicone sealant for portions exposed outdoors.
3. Expansion Joints: Bellows type.
4. Options and Accessories:

    a. Inner Wall: 304 SS
    b. Outer Wall: Aluminized steel 304 SS.
    c. 12-year warranty against defects in materials and workmanship
    d. Uninsulated with minimum 1-inch space between inner and outer walls. Metal Fab Type PIC.

D. Type IV Vent: For use with Category II or Category IV appliances (natural gas or propane-fired, positive or negative pressure, condensing, not exceeding 550º F exhaust temperature). Listed per UL-1738, double wall with 1-inch clearance and spacers to maintain alignment.

1. Inner Pipe: AL2904C superferritic SS manufactured by Allegheny Ludlun, with welded seams, connected with V-bands, and sealed with high temperature silicone sealant. Rated at 6 inches water. Thickness: 0.015-inch through 12-inch size; 0.024-inch for 14-inch and larger sizes.
2. Outer Pipe: Seal with V-band of same material as outer pipe. Provide silicone sealant for portions exposed outdoors. Thickness: 0.018-inch through 12-inch size; 0.024-inch for 14-inch and larger sizes.
3. Options and Accessories:

    a. Outer Wall: Aluminized steel 304 SS.

4. Metal Fab Type CG

2.4 DAMPERS FOR FIRE AND SMOKE CONTROL

A. General: Factory assembled and UL listed as an assembly, suitable for horizontal or vertical air flow and for ducted or un-ducted applications. Fire dampers (FDs) shall be listed per UL 555, smoke dampers (SMDs) shall be listed per UL 555S, and fire/smoke dampers (FSDs) shall be listed per UL 555 and UL 555S. Units shall be galvanized steel except as noted. Approved manufacturers: Greenheck, Ruskin, Potorff, or approved equal.

B. Combination Fire/Smoke Dampers: Factory assembled complete with damper, actuator, thermal link, and all specified accessories, all mounted on a sleeve.

1. Construction: Round blades, rectangular parallel blades and rectangular opposed blades are acceptable, except dampers shall be rectangular opposed blade type when installed in any of the following conditions: within 10 diameters of a fan or supply register, within 3 diameters of an elbow. Internal frames in rectangular FSDs shall be low profile type for

ducts 17"H and less.

2. All components factory installed and wired, including actuator, thermal link, position switches, temperature over-ride (if specified), test switch (if specified), etc. Mount all such components on outside of FSD sleeve to the side of duct (not top or bottom) except where indicated or approved. FSDs must be suitable for rotating the unit 180-degrees so these components can be on either side of the duct.

3. Air pressure drops shall be certified per AMCA 500D. Pressure loss coefficient C_o shall not exceed the following when tested per AMCA Figure 5.3:

Size (in)	3-V Blade	Airfoil Blade	Round
12 x 12	2.41	2.01	NA
24 x 24	0.65	0.60	NA
36 x 36	0.44	0.27	NA
12 x 48	0.76	0.91	NA
12 Round	NA	NA	0.33
24 Round	NA	NA	0.23

4. Listed for installation within wall, floor or ceiling assemblies as indicated on drawings.

   a. Ratings, except as noted: 1.5-hr Fire Rated, Leakage Class 1, 350°F, 4-inch Static Pressure, Dynamic.
      1) Up to 1600 FPM: Greenheck FSD-211 (3-V blade type), OFSD-211, or FSDR-511 (round).
      2) Up to 3000 FPM: Greenheck FSD-311 or 311V (airfoil blade) or OFSD-311.
   b. 3-Hr Rated Walls: Greenheck FSD-231.
   c. Stainless Steel: Greenheck SSFSD-211 or SSFSDR-511 (round).

5. Actuators: Electric 2-position, 115/1/60 (provide factory wired transformer if required), normally closed, spring return, NEMA-1 except as noted. Actuator shall fully re-open damper when power is restored after any power interruption.
6. Accessories

   a. Transitions: Provide round-to-rectangular, oval-to-rectangular, or rectangular-to-rectangular transitions as appropriate for the application.
   b. Thermal Link: Provide re-settable bi-metallic thermal link to initiate closure when the air temperature within the duct rises to 165° F. Where indicated provide thermal links for operation at 212° F, 250° F, or 350° F. Thermal link shall be easily resettable from outside the duct.
   c. Position Switches: Provide dry contacts for remote monitoring of damper open and closed positions.
   d. Retaining plates and angles: Provide as required. Galvanized steel specifically designed for the particular FSD and included as part of the UL Listed assembly.
   e. Installation decals: Provide installation decals on the sleeve which give the installer clear installation instructions.
   f. Temperature Override Control: Provide controls so that the thermal link can be over-ridden and the FSD opened for smoke control, even if the air temperature exceeds the setting of the thermal link, provided the temperature does not exceed

350° F.

C. Smoke dampers: Similar to fire/smoke dampers noted above, except as follows:

1. Smoke dampers shall comply with UL 555S, but need not comply with UL 555.
2. Smoke dampers need not have a fire rating.
3. The thermal link and temperature override are not applicable.
4. Suitable for installation within a wall, floor or ceiling assemblies as indicated.

a. Ratings, except as noted: Leakage Class 1, 350° F, 4-inch Static Pressure, Dynamic.
   1) Up to 1600 FPM: Greenheck SMD-201 (3-V blade type) or SMDR-501 (round).
   2) Up to 3000 FPM: Greenheck SMD-301, 301V (airfoil blade) or SMDR-401.
b. 6-inch pressure rated: Similar to Greenheck SMD-401
c. Stainless Steel: SSSMD-201 & SSSMDR-501 (round).

D. Fire Dampers: Dynamic rated, suitable for closing against 8-inch differential pressure. Curtain type with sleeve and 165°F replaceable fusible link, resettable. Provide round-to-rectangular, oval-to-rectangular, or rectangular-to-rectangular transitions as appropriate.

1. 1.5-hr rated: Greenheck DFD-155
2. 3-hr Rated: Greenheck DFD-355.
3. Provide 212° F fusible links for high temperature applications.

E. Ceiling Radiation Dampers: UL Classified for use with fire rated floor/ceiling assemblies, with 165°F fusible link replaceable through the damper assembly, 1.5-hr rated except as noted. Greenheck CRD-1, CRD-2 (round), CRD-60, or CRD-60X. Provide 212° F fusible link and 3-hr rated dampers where indicated.

2.5 FILTERS AND FILTER GAUGES

A. Rated per ASHRAE Std. 52.1; Class 1 or 2 per UL Std. 900; glass fiber media; suitable for operation from -20° F to +170° F; corrosion resistant; suitable for installation with pleats either horizontal or vertical, and for air flow horizontal, vertical upflow, or vertical downflow; suitable for face velocity up to 625 FPM. Unless specified elsewhere, pre-filters shall be MERV-8, and final filters (where specified) shall be MERV-13. AAF, Camfil Farr, or approved equal.

		MERV RATING						
		7	11	14	11	14	11	14
Description							High Capacity	
Configuration		2-inch or 4-inch	12-inch Cartridge		6-inch Cartridge		12-inch Cartridge	
Initial Resistance	in. wg.	0.26	0.25	0.58	0.39	0.58	0.29	0.49
Rated Velocity	FPM	500	500	500	500	500	500	500
Max Velocity	FPM	625	625	625	625	625	750	750
Recommended	in. wg.	0.7	1.5	1.5	1.5	1.5	1.5	1.5

Final Resistance								
Gross Media per 24 x 24 Filter	SF	14 Pleats per foot	62	62	105	125	175	175
Housing		Cardboard	Polystyrene or Aluminized Steel	Polystyrene or Aluminized Steel	Polystyrene or Aluminized Steel			
Frame		Channel	Gasketed		Gasketed		Gasketed	
AAF Model		Perfect Pleat	VariCel RF		VariCel M-Pak		VariCel V	
Camfil Farr Model		3030	RigaFlow					

B. Filter Gauges: Provide a filter gauge for each bank of filters. Gauges shall be magnehelic type with static pressure tips and inter-connecting piping. Ranges shall be 0-1 inch w.g. for all filters except bag filters which shall have a range of 0-2 inches w.g.

2.6 TERMINAL UNITS

A. General: Factory packaged unit with casing, air valve, air flow sensor. If the following sections are specified or required, provide them as part of the factory package: heating section, fan, and sound attenuator. Terminal units (TUs) shall be suitable for variable volume operation over the scheduled air flow ranges. Air flow and sound performance shall be rated per ARI 880. All materials in the air stream shall comply with the requiements of UL-181 and NFPA-90A.

1. Unit Construction:

a. Casing: Minimum 22-gauge galvanized steel with round inlet collar, rectangular outlet collar, 3/4-inch acoustic lining with cut edges coated with sealant.
   1) Provide aluminum foil liner over acoustic lining in casing and all accessory sections (e.g., sound attenuator). Liner shall comply with:
      a) UL 181 – Air Erosion, Mold Growth & Humidity
      b) UL 723 – 25/50 flame & smoke
      c) ASTM E84 – 25/50 flame & smoke
      d) ASTM C665 – Fungi Resistance

b. Air Valve: Heavy gauge metal damper, shaft to extend through casing, self-lubricating bearing, with leakage not to exceed 2% of rated air flow when closed with 3-inch inlet pressure.

c. Air Flow Sensor: Cross configuration located at inlet of assembly, accurate to within 5% with 90º elbow directly at inlet connection. Provide

d. Sound Attenuator: Galvanized steel with acoustic lining. Provide aluminum liner if specified for casing.

e. Heating Section:
   1) HW Coils: Copper tubes, aluminum fins, galvanized steel casing, sweat connections, ARI rated, minimum 300 psi rated. Size heating coils for the capacities indicated on the equipment schedule. Provide single row coils wherever they can do the specified heating duty. Provide 2-row coils where indicated and where required for the indicated heating capacity. Do not exceed 0.5-inch static pressure drop for the entire unit (terminal unit, heating coil and sound attenuator). Where necessary to limit pressure drop, either

over-size unit or provide a separate, larger (lower pressure drop) heating coil to be installed in the discharge ductwork.

2) Electric Heaters: Factory installed and wired with all necessary safety controls, UL listed as an assembly, with galvanized steel enclosure, 80/20 nickel chrome heater elements, electronic modulating control with 4-20 mA input signal from DDC system, air flow switch, access door with door interlock disconnect switch, automatic reset primary thermal cutout switch, manual reset secondary thermal cutout, 24-V control transformer, NEMA-1 enclosure for all electrical components with hinged access door with wiring diagram. Controller shall be solid state type to minimize electrical interference and for silent operation.

2. Sound Data: The equipment schedules show maximum allowable NC levels based on unit sound power measured per ARI-885, and sound attenuation per ARI-885 Appendix E with a Type 2 ceiling. Do not exceed the scheduled sound levels.
3. Controls: Controls will be supplied by the controls contractor for installation by terminal unit (TU) supplier. Coordinate with controls contractor who will ship controls to TU manufacturer. TU manufacturer shall install controls onto terminal units.
4. Approved Manufacturers: Price, Anemostat, Titus, Krueger, or approved equal.

B. VAV Reheat: Single duct type with reheat as indicated, Price SDVQ5.

C. Fan Powered: Parallel flow type with backdraft damper at fan discharge. Electric heating coil may be in total air stream, but HW coil must be in secondary air section. Capable of providing heating to space with primary air system shut down. Provide collar to allow ducting the secondary air inlet. Price FDV or approved equal.

1. Fan: Forward curved, steel, dynamically balanced, direct drive, ECM motor with permanently lubricated bearings and thermal overloads.
2. Electrical:

D. Dual Duct: With separate air flow sensor and air valve for hot and cold air streams, and ari flow sensor in the mixed outlet air stream, suitable for variable volume operation, Price DDQ.

2.7 GRILLES, REGISTERS AND DIFFUSERS

A. General: Performance rated per ASHRAE Std 70, *Method of Testing for Rating the Performance of Air Outlets and Inlets*, steel with baked white enamel finish except as noted, for installation on a fixed surface or a lay-in T-bar ceiling as indicated on architectural drawings, rigidly constructed, vibration free, with inlet collar of sufficient length to connect inlet ductwork, sized as shown on drawings. Where frames are provided for installation in fixed surfaces, frames shall be approximately 1-1/8" wide. Sound performance rated per ADC and based on room absorption of 10dBre10^{-12} Watts and one diffuser.

1. Approved Manufacturers: Price, Krueger, Titus, Anemostat, OAE

B. Types as follows. See also the Grille and Diffuser Schedule on drawings.

1. Square Ceiling Diffusers: Louvered type, 4-way pattern, 1-piece smooth aerodynamic surfaces with no corner joints, three louvers for 12-inch sizes, four louvers for 24-inch

sizes, removable louver assembly, round neck, to provide stable, horizontal air flow without dumping down to 75 FPM inlet velocity for ceiling applications, and down to 20% of maximum air flow for non-ceiling applications. Price SCD.

2. Round Ceiling Diffusers: Louvered type, 360-degree distribution, four separate 1-piece smooth aerodynamic louvers, adjustable air flow pattern (horizontal vs. vertical), round neck. Price RCD.
3. Ceiling Return, Exhaust and Transfer Grilles: 1/2" x 1/2" x 1/2" egg crate type, steel frame for surface mounting or T-bar ceiling per application, aluminum grid. Price Series 80.
4. Ceiling Rectangular Directional Diffusers: Louvered type, directional pattern as indicated on drawings, with removable louver assembly. Price SMD.
5. Sidewall Supply Registers: Double deflection with ganged horizontal front bars, individually adjustable vertical rear bars, 3/4" bar spacing and surface mounting frame. Price 520.
6. Sidewall Return, Exhaust and Transfer Grilles: Fixed horizontal bars on 3/4" centers set at 30-45 degrees, surface mounting frame. Price 530.
7. Ceiling or Sidewall Linear Supply Diffusers: Extruded aluminum with baked white enamel finish, frame suitable for lay-in or surface mounting as per the architectural drawings, all aluminum construction, flat black interior surfaces, air flow deflection vanes to provide each slot with individually and fully adjustable 180^{o} air pattern from horizontal to vertical or in between, self-aligning devices to ensure proper alignment where multiple sections are required, and corner pieces as necessary for a continuous appearance. Provide galvanized steel side inlet plenum matched to diffuser, with plenum extension if necessary to match adjacent construction. Performance data is based on 3/4-inch slots unless otherwise indicated. See plans for required air flow, diffuser length, and number of slots. Price SDS with SDA or SDB plenum, Krueger 1910, or equivalent.
8. Ceiling or Sidewall Linear Return Registers: As specified for sidewall linear supply diffuser except without air flow deflection vanes. Price SDS.
9. Stainless Steel Sidewall Return/Exhaust Registers: Fixed horizontal blades at 1/2" spacing and 45^{o} deflection, flange for surface mounting, and SS 90^{o} quick-release fasteners to mount grille to frame. Provide mill finish for blades and No. 4 finish for flanges. Price Model 735H.
10. Stainless Steel Slot Diffuser: Consist of a 0.037", 304 stainless steel plenum with continuous welded joints and chamfered corners to facilitate cleaning. The diffuser face shall be stainless steel construction with slots and fixed pattern deflectors. Plenums shall have stainless steel inlet collars complete with removable dampers from plenum face. The removable dampers shall be opposed blade type, constructed of stainless steel. Damper shall be adjusted without removing face of diffuser. The diffuser face shall be attached by stainless steel 90^{o} quick-release fasteners and safety cable to open easily. The diffuser face, mounting frame, face and interior surface of plenum shall have a #4 finish. Krueger Model HORDSS or equivalent.
11. Laminar Flow Diffuser: Extruded aluminum construction and plated steel to inhibit corrosion. The perforated face plate, damper deflector, interior baffles and diffuser back pan plenum assembly shall be of 0.040 aluminum. The perforated face plate shall open easily with 90^{o} quick-release fasteners and safety cable for easy cleaning and damper adjustment. B11 Sterile White-Thermal Setting finish. Krueger Model LFD or equivalent.

2.8 FANS

A. General

1. Construction

a. Factory fabricated fan, motor, drive and accessories, listed per UL, with air flow rated per AMCA 211 and sound rated per AMCA.
b. Fan wheel: Statically & dynamically balanced, with shaft sized so first critical speed is minimum 25% above maximum operating speed.
c. Motor and Drive: Premium efficiency ODP motor per Spec Section 23 0500, direct drive or belt driven as indicated in schedule on drawings, bearings with 100,000 hr L-10 life.
   1) Variable Speed Applications: Provide Class F insulation.
d. Belt Drives: Adjustable pitch sheave up to 5 Hp, fixed pitch above this Hp, cast and machined pulleys with all components sized for 150% of motor Hp.
e. Dampers:
f. Accessories:
   1) Roof Curb: Minimum 14-inch galvanized steel, fiberglass insulated, with wood nailer, damper tray and flange. Provide cant and step if needed for proper seal with roof.

2. See Section 23 0548 for Vibration Isolation requirements.

B. Centrifugal Roof Exhaust Fans

1. Leakproof construction.
2. Housing: Spun aluminum construction, reinforced wind band welded to one-piece curb cap with mounting holes on the side and integral spun venturi, spun aluminum motor compartment with readily removable cover and breather tube. All other structural components shall be galvanized steel.
3. Fan wheel: Backward inclined, centrifugal, non-overloading.
4. Motor and Drive: Motor out of the air stream, cooled with ambient air. Motor, drive and fan wheel resiliently mounted on neoprene isolators.
5. Electrical: Disconnect NEMA-1 if protected from the weather, or NEMA-3R if exposed to the weather, wired to motor, with all wiring and components per NEC and either UL Listed or UL recognized.
6. Accessories: Stamped aluminum nameplate, hinge kit to allow tilting fan up to inspect wheel, retaining chains, conduit chase and roof curb.
7. Approved Manufacturers: Greenheck Type, G, GB, CUE or CUBE as indicated. Cook, ACME, OAE.

C. Laboratory Exhaust Fan

1. General: Factory fabricated, weatherproof for rooftop installation, with inlet plenum, fan assembly, bypass damper and discharge assembly, listed per UL 705.

a. Heavy gauge welded steel, powder costed, chemical and UV resistant, designed for wind speeds up to 125 MPH without guy wires,
b. Intake Plenum: With bypass dampers (low leakage airfoil type, corrosion resistant, similar to Greenheck), intake hood with bird screen, access panel, and roof curb.
c. All driveline components (motor, belt, drive, bearings, etc) located outside the contaminated air stream, and replaceable without exposure to the contaminated air

stream. Belts & drives sized for 200% of motor HP, bearings sized for 200,000 hr L-10 life, shaft seal, AMCA Class B or C spark resistant construction,

2. Mixed Flow Fan Style: Mixed flow fan with fan, motor and drive resliently mounted on neoprene-in-shear isolators.
3. Centrifugal Fan Style: Backward inclined fan, housing with access door, fan and motor mounted on rigid steel frame, spring isolators with minimum 1-inch static deflection, and fabric inlet flexible connector.
4. Accessories: Color as selected by architect from among manufacturer's standard colors, windband acoustic attenuator, double wall plenum, isolation damper, roof curb, and factory wired electrical disconnect.
5. Approved Manufacturers: Greenheck Model MD or CD, Strobic Air, OAE.

2.9 COILS

A. Galvanized steel casing, copper tubes and aluminum fins except as noted, with tubes mechanically expanded into fins, circuited to allow completely draining and venting coil, drain and vent connections, with performance rated per ARI. Do not exceed scheduled air or water pressure drops by more than 5 percent.

2.10 AIR HANDLING AND AIR CONDITIONING UNITS

A. General

1. Acoustical performance shall be established per ARI 260 rating procedures. Measurements will be taken in an ANSI 12.32 qualified room using a calibrated reference source per ARI 250. Sound data supplied shall meet or be less than requirements established later in this Specification. (Data presented in dBA, sones, Bels is not acceptable.)

B. Packaged AC Units, 2 – 12.5 Tons

1. General: Factory fabricated with ductwork connections as indicated on the drawings, suitable for rooftop installation, UL listed, ARI rated, factory piped and wired requiring only a single field power connection, factory run-tested, with casing, cooling section, gas heating section, fan section, accessories and controls.
2. Casing: Heavy gauge galvanized steel, weatherproof with exterior surfaces phosphatized and finished with baked enamel, hinged or removable panels for access to all components, water and air-tight seals for access panels, minimum 1/2-inch insulation, and hoods for intake and relief air. Provide a location for locating a fused disconnect on exterior of unit.
3. Cooling Section: Suitable for operation down to 55^{o} F ambient, hermetic compressors, evaporator and condenser coils with copper tubes mechanically expanded into aluminum fins, all necessary refrigerant accessories, all necessary safety and operating controls, and double-pitched condensate pan. Provide fan guard for condenser fans.
4. Heating Section: Gas-fired, SS burner, corrosion resistant heat exchanger, direct spark ignition, forced draft or induced draft fan, all necessary safety and operating controls, complying with California requirements for low NOx emissions.
5. Fan Section: Forward curved centrifugal, direct drive, with thermally protected motor,

resiliently mounted.

6. Economizer: May be field installed, automatic motorized intake damper for 0 – 100% outside air intake, dry bulb type, with relief damper.
7. Accessories: 2-inch MERV 8 filters, 12-inch insulated roof curb with wood nailer and with cant and/or step if required to coordinate with roof.
8. Controls: Factory wired 24V microprocessor controls with controls transformer and thermostat for wall mounting.
9. Approved Manufacturers: Trane, Carrier, York, OAE.

C. Rooftop Direct-Fired/Evap Cooled Makeup Air Unit

1. General: Factory fabricated, packaged rooftop, direct-fired with evap cooling, ETL Listed to ASNI Z83.4-1999, factory wired and tested (gas train, electrical components and air flow controls),
2. Unit Construction: Heavy gauge G90 galvanized steel casing with corrosion resistant fasteners, weatherproof with standing seam where roof panels are joined, all metal-to-metal surfaces sealed where exposed to the weather, 1-inch fiberglass insulation, discharge configuration as indicated on drawings, access doors or removable panels for ready access to all components, and lifting lugs.
3. Heating Section: Direct fired with cast aluminum burner, for use with natural gas at 900 – 1000 Btu/SCF HHV, SS mixing plates, Maxitrol or equivalent controls with 25:1 turndown, IRI or FM gas train, and all necessary safety and operating controls.
4. Cooling Section: Evaporative type, SS module construction, 12-inch media with 90% cooling effectiveness, with float-type makeup, 120V pump with discharge piping and corrosion-resistant distribution header, drain & overflow connections.
5. Fan Section: AMCA rated for both performance and sound, centrifugal type statically and dynamically balanced, permanently lubricated bearings with 100,000 Hr L-10 life at maximum cataloged speed, belt driven with drive sized for 150% of motor HP, pulleys with machined surfaces, adjustable sheaves for 15 Hp and less, motor per Section 23 0500, fan discharge flexible connection, and with fan and motor mounted on common base.
6. Electrical and Controls: Factory wired for service from a single-point power connection, with all necessary power and control components mounted in accessible and weather-protected enclosures, all wiring per the NEC, control transformer with secondary fusing, contacts for remote start/stop and monitoring of fan status, and discharge temperature sensor with all components necessary for discharge temperature control. All components UL listed, recognized, or classified where applicable.
7. Accessories: Double wall construction, motorized intake damper, 2-inch aluminum mesh filters sized for less than 550 FPM, dirty filter switch, fan and motor base spring isolated with minimum 1-inch static deflection, discharge fan configuration as shown on drawings, inlet weather hood with bird screen, louvered inlet with bird screen, minimum 12-inch insulated roof curb of G90 galvanized steel, evaporative cooler media with Class II rating per UL 900 (e.g., GLASdek), automatic blowdown controls (timed blowdown is acceptable), disconnect switch, fan motor starter, premium efficiency motor, and 115V convenience receptacle in NEMA 3R enclosure.

    a. Variable Volume: Class F motor insulation and automatic burner bypass damper (may be self-adjusting) to ensure proper burner operation under the full range of operating conditions.

8. Approved Manufacturers: Greenheck Model DGX, Spec Air, Trane, Reznor, or

approved equal.

PART 3 - EXECUTION

3.1 DUCTWORK AND PLENUMS

A. Ductwork

1. Construct ductwork with wall thicknesses and reinforcing per the SMACNA HVAC Duct Construction Standards, Second Edition, 1995, and UMC 2006 Chapter 6,
2. Pressure Classes: Construct ductwork to the following pressure classes:

Duct Element Description	Relative Pressure	Pressure Class
From Outside Air Louver to Filter:	N	1"
From Air Handling Unit to Terminal Unit:	P	4"
From Single Zone AHU to Diffuser	P	2”
From Terminal Unit to Diffuser:	P	1"
From Return Grille to Fan:	N	1"
From Return Fan to Relief Louver:	P	1"
From Exhaust Register to Exhaust Fan:	N	2"

3. Minimum thickness for sheet metal ductwork: 26 gauge.
4. Sealing: Seal ductwork and plenums as follows:

	Seal Class			
	Supply Ducts			
Location	≤2 in. wg	≥2 in wg	Exhaust	Return
Outdoors	A	A	C	A
Unconditioned Spaces	B	A	C	B
Conditioned Spaces including RA Plenums	C	B	B	C

Seal Class	Description
A	All transverse joint, longitudinal seams and duct wall penetrations.
B	All transverse joints and longitudinal seams.
C	Transverse joints

a. Apply duct sealer to inside of seams and joints. Do not use pressure sensitive tape as the primary sealant.

5. Clearance to earth: Maintain minimum 4-inch separation between ductwork insulation and earth.
6. Openings in Ductwork: During installation protect the open ends of ducts to prevent debris and dirt from entering.
7. Provide turning vanes in square elbows of low velocity supply and exhaust ductwork.
8. Collars: Where exposed ducts pass through walls, floors, or ceilings, provide a tight-

fitting, flanged sheetmetal collar around duct and tight against finished surface to cover opening and present a neat appearance. Lock collar to duct.

9. Cross Breaking: Cross-break low velocity rectangular sheetmetal ducts on all four sides. Cross break sheet metal between standing seams or reinforcing angles. The center of cross break shall be of the required height to assure surfaces being rigid. Do not cross-break high velocity plenum panels.
10. Grilles Registers and Diffusers: Install plumb, affix to general construction as appropriate, make air-tight connection to ductwork, and adjust air flow pattern to achieve appropriate velocities in the occupied zones. Request direction from Engineer if any question exists regarding proper air flow adjustment.
11. Duct Thermometers: Provide thermometers to indicate mixed air, outside air, and supply air of indoor air handling units over 2,500 cfm and where shown on the Drawings.
12. Test Holes: Provide test holes in ducts at locations where testing is required per Section 23 0593 and as requested by the T&B agent. Close test holes with rubber plugs. Reseal all insulated ductwork with the same insulation, jacket and vapor barrier material after T&B is complete.
13. Closure Systems:

    a. Rigid Air Ducts: Comply with UL 181A – Standard for Closure Systems for Use with Rigid Air Ducts and Air Connectors.
    b. Flexible Air Ducts: Comply with UL 181B – Standard for Closure Systems for Use with Flexible Air Ducts and Air Connectors.

14. Factory Made Air Ducts: Install in accordance with the terms of their listing and the manufacturer's recommendations.
15. Acoustic Insulation: See Section 23 0700, HVAC Insulation. Fabricate ductwork so the dimensions indicated on the drawings are the clear dimensions for air flow inside the acoustic insulation.
16. Coordination with Building Construction

    a. General: The drawings show the general intended configuration of the ductwork. Provide additional offsets where necessary to coordinate with the building construction or with the work of other disciplines. Transition ductwork as required at no change in contract price. Where this is necessary, submit for review and maintain the indicated flow areas.
    b. Ductwork is frequently routed through bar joists and between bar joists. Coordinate duct locations with joist submittals prior to fabrication.

B. Special Applications

1. Moisture Laden Ductwork: Stainless steel with all joints liquid-tight by continuous external welding. Welds shall be free from pits, runs, spatter and other imperfections. Pitch horizontal ductwork downward to intake opening. Where traps occur that collect water, provide a 1/2-inch half coupling welded to the bottom of the duct and pipe to spill over nearest drain. Include a properly sized trap in the drain piping.
2. Fume Hood Ductwork: Stainless steel with seams and joints continuously welded on the exterior. Spiral lock seam is <u>not</u> acceptable.
3. Shower Room Exhaust Ductwork: Aluminum
4. Ducts Handling Corrosive Vapors: Either stainless steel or galvanized steel with internal polyvinyl coating constructed and sealed as noted.

5. Fiberglass Ductwork (Ductboard)

    a. Provide fiberglass ductboard only where specifically indicated on the drawings and in this specification.
    b. Install per UMC-06 Standard 6-05 – Standard for Installation of Factory-Made Air Ducts and SMACNA Standard 1884-2003 – Fibrous Glass Duct Construction Standard.
    c. The drawings indicate required clear inside dimensions for air flow.
    d. Where a duct constructed of ductboard penetrates a wall or floor which requires a fire damper, smoke damper, or fire/smoke damper, install the FD, SMD or FSD in the wall per its listing, make sheet metal connections to the damper if required, and then transition back to ductboard.

6. Exterior Ductwork: Install ductwork as specified herein and insulate per Section 23 0700. Then enclose the exposed top and sides of ductwork with 28 gauge galvanized steel or 26-guage aluminum to protect the insulation. Repair any damage to the insulation jacket. Slope sheet metal enclosure to shed water.

C. Hangers and Supports

1. Securely support ducts per SMACNA and UMC Table 6-7. Provide support at each concentrated load and at each change in direction. Provide supports on each side of rectangular ducts and equipment. Where vertical ducts pass through floors or roofs, support with angles or other steel members attached to minimum two opposite sides of duct. Size supports to rigidly support the ductwork. Provide lateral support.
2. Hangers for terminal units: Minimum four 1" x 1/8" galvanized steel straps or two angle trapeze supports.
3. Horizontal Round Ducts: 30 inches and larger in diameter: Provide 2" x 2" x 1/8" black steel rolled angle ring on 6-ft centers, and support from angle.

D. Plenums

1. Single Wall Plenums: Shop fabricated minimum 16 gauge galvanized sheet steel. Horizontal and vertical panels are to be fabricated of 2' x 10' sheets. Unless otherwise dimensioned on the Drawings, access door frames are not to exceed 16-3/4 inch width. Where door width exceeds 16-3/4 inches, vertical panels shall be fabricated around 2" x 2" x 1/4" angle. If the plenum height or width exceeds 9 feet, provide a 2-1/2" x 1/8" continuous galvanized steel strip between each horizontal and vertical seam. Provide high velocity cement at each joint during panel assembly. Panels are to be bolted as shown on the details or tack welded at the Contractor's option; however, enough panels must be bolted to allow removal of equipment from the plenums. Cover interior surfaces with 2-inch thick, acoustical lining.

a. Plenum Access Doors: Minimum two fastening devices that can be operated on either side of the door; these devices to be readily operated and moving parts to have bronze pins. All parts of the door shall be constructed of galvanized iron and shall be airtight. Latches: "Ventlock" No. 310 OAE.

2. Double Wall Plenums: Factory fabricated, Semco or equivalent. Submit shop drawings for review including overall configuration, construction details, access doors, erection drawings and structural calculations stamped by a registered structural engineer,.

a. Factory fabricated, minimum 18 gauge galvanized steel outside, perforated galvanized steel inside, with 2-inch sound insulation between. Plenums downstream of final filters shall have solid inner panel.
b. Heat transfer coefficient shall not exceed 0.0575 BTUH/SF-F at 75 deg F mean temperature. Pressure Ratings: 12 in. wg positive and 10 in. wg negative.
c. Noise attenuation shall be as follows in decibels, re 10^{-12} watts.

	OCTAVE BAND							
	1	2	3	4	5	5	7	8
Attenuation, db:	26	30	36	41	34	36	44	37
Noise Absorption Coeff:	0.22	0.39	1.20	1.36	1.03	0.84	0.74	0.68

3.2 DUCTWORK ACCESSORIES

A. Dampers: Install dampers with shafts horizontal. Locate dampers so that actuators are readily accessible. Verify that dampers operate smoothly.

1. Manual Dampers (Balancing Dampers): Damper Types D1 through D23 are all suitable for use as manual balancing dampers. Provide locking quadrants.
2. Automatic Applications: The following damper types may be used for automatic applications: D4, D5, D6, D7, D21, D22 and D23. Provide damper actuators per Section 23 0900.

B. Flexible Connectors: Provide flexible connectors at locations indicated on the drawings and at the inlet and outlet of each fan directly connected to duct system. Select flexible connectors appropriate for the application. Provide steel spring vibration isolators spanning across flexible connections of isolated fan housings to prevent blow-apart due to horizontal displacement of fan housings.

C. Access Doors: Provide as required for access to all components located within ductwork. Locate to facilitate access to such components. Size as appropriate. In addition to locations specifically called out on the drawings or elsewhere in these specs, provide access doors at the following: FDs, SMDs, FSDs, instrumentation mounted within ductwork, fan bearings.

D. Turning Vanes: Provide turning vanes in square elbows of all supply ducts. Single wall turning vanes may be used in ducts up to 1500 FPM and 24-inch vane length. Provide double wall turning vanes in ducts exceeding either of these criteria.

E. Roof Curbs and Equipment Support Rails: Coordinate the location of roof curbs and rails with the roof structure, ductwork distribution, and other work. Install after roof deck is installed but before roof is insulated. Mount curbs and rails securely to deck per manufacturer's recommendations. Provide counterflashing as required.

F. Louvers: Coordinate louver size and construction with structural and architectural openings to assure proper fit. Securely fasten louver to internal structural members to withstand a force of 25 lb/sf plus a safety factor of 3.0.

G. Instrumentation: Install duct thermometers and filter gauges so they are easily readable from the operator level.

3.3 FLUES AND VENTS FOR FUEL-FIRED EQUIPMENT

A. General: Install per the drawings and these specifications, manufacturer's instructions, the terms of the vent's UL Listing, the UMC and NFPA-211.

1. Use the same type vent for the entire system from the equipment connection to the termination outside. Provide all fittings, transitions, adapters, supports, storm collars, etc.
2. Install per the venting requirements of the appliance manufacturer. Comply with clearances per UL Listing. Minimize offsets and resistance to flow. System shall develop a positive flow adequate to remove products of combustion to outside. Do not run any portion of the vent system through any supply or return air duct or plenum. Do not connect the vent from any Category I or II (non-positive pressure) appliance with any Category III or IV (positive pressure) appliance. Do not install any manually operated damper at any point in vent system.
3. Properly support the system and make provisions for thermal expansion. Install so as to prevent leakage of flue gases into the building. Provide drain connections where condensate is likely to accumulate, and pipe to spill over floor drain.
4. Provide ventilated thimbles where vents pass through walls, floors and roof. Paint all galvanized or aluminized steel parts exposed to the weather with one coat of corrosion and heat-resistant primer, and one coat of heat resistant paint.
5. Terminate low heat appliances as indicated on the drawings, but not less than:

    a. 3 ft above the highest point where the vent passes the roof.
    b. 2 ft above any portion of a building within a horizontal distance of 10 ft.
    c. 3 ft above any forced air inlet located within 10 ft.

B. Type B: If a draft damper is supplied with the appliance for installation in the flue, install it per manufacturer's instructions. If appliance is listed for use with a draft hood but is not supplied with one, provide a properly sized barometric draft regulator immediately in the vent outlet, and install per manufacturer's recommendations. Pitch vent up minimum 1/4-inch per foot. Join sections per manufacturer's recommendations using sheet metal screws or proprietary closure system of a UL Listed venting system. Provide vent cap,

C. Type III and IV: Install per the drawings and these specifications, per manufacturer's instructions, per the terms of the vent's UL listing, and per NFPA-211.

3.4 DAMPERS FOR FIRE AND SMOKE CONTROL

A. Select FDs, SMDs and FSDs as appropriate to the application. Dampers may be rectangular or round, and single-section or multi-section as required, but shall not be less than the duct sizes indicated on the drawings nor larger than the maximum sizes per the UL listing for a given style of damper. Provide transitions and sleeves as required.

1. FSDs may be used where SMDs are indicated provided they meet the required ratings of the indicated SMDs and provided the FSDs are installed in accordance with their listing.

B. Install dampers in accordance with their listing. Terminate acoustic lining at dampers as necessary to ensure proper damper operation. Install actuators and access doors on the side of the duct unless space conditions preclude this. Provide adequate clearance for proper operation, and minimum 36-inch clearance for servicing actuator.

1. When space conditions preclude installing actuators on the side, such components may be installed on the top or bottom of the duct provided good access to these components is maintained.
2. When size requires the use of multiple dampers, provide framing to ensure the dampers remain in place.
3. Provide a duct access door at each FD, SMD and FSD for inspection and maintenance. Provide minimum 1/2-inch high label, “SMOKE DAMPER,” “FIRE DAMPER,” or “FIRE/SMOKE DAMPER.”

C. Test all SMDs and FSDs after the system is installed to ensure proper operation based on both smoke and fire signals. Advise Owner minimum 2 weeks in advance and invite him to observe these tests. Submit a written report with a table which identifies each such damper (along with plans which indicate each such damper); gives its size, type and model number; the date on which it was tested; the test results; and places for the initials of the person performing test for the contractor and the person witnessing test for owner. Should any dampers fail to operate properly, service them and demonstrate proper operation. Reset all dampers when the testing is complete.

3.5 FILTERS AND FILTER GAUGES

A. Provide one set of MERV-8 temporary filters until testing and balancing is complete. Then immediately before the system is turned over to the Owner at the completion of the project, remove these filters and provide the specified filters.

3.6 TERMINAL UNITS

A. Install terminal units so that controls and piping components are readily accessible for normal service and maintenance. Provide minimum 3 ft clear in front of control panels.

3.7 GRILLES REGISTERS AND DIFFUSERS

A. Install grilles, registers & diffusers (GRDs) square with building construction. Mount sidewall GRDs minimum, 3-inches above floor level. If GRDs have provisions to adjust the direction of air flow, submit a written recommendation regarding the best direction for air flows, obtain

written approval from the Owner's Representative, and adjust GRDs accordingly.

B. Verify frame types with architectural RCPs prior to ordering GRDs.

3.8 FANS

A.

3.9 COILS

A.

3.10 AIR HANDLING UNITS AND AIR CONDITIONING UNITS

A.

3.11 CLOSEOUT ISSUES

A. Leakage Testing

1. Pressure test not less than 25% of the installed ductwork of each system rated at 3 in wg or more, either positive or negative pressure. Advise Owner's Representative when systems will be ready for testing. For large systems separate tests may be made on different sections. The Owner's representative will designate the sections to be tested, but not more than 24 hours in advance of test. Cap ends of ducts as required and provide equipment as required for testing.
2. Measure duct leakage per the SMACNA HVAC Duct Leakage Test manual. Leakage shall not exceed the following:

   $L_{max} = C_L P^{0.65}$, where
   L_{max} = maximum permitted leakage, cfm/100 sf of duct surface area
   C_L = Duct leakage class (cfm/100 sf at 1-inch wg)
   = 6 for rectangular sheet metal, rectangular fiberglass, and round flexible ducts
   = 3 for round and flat oval sheet metal or fiberglass ducts
   P = Test pressure. Test pressure shall match system pressure class.

3. If sample is defective, the contractor shall repair or modify the defective section and re-test it to demonstrate compliance. In addition, for each section which fails its original pressure test, the Owner's Representative will designate an additional ductwork section of similar size, for the Contractor to test. This section will be in addition to 25% area originally planned to be tested. .
4. Complete all leakage testing and repairs prior to concealing ducts.
5. Submit a test report that documents the test procedure and results. Include:

   a. Test equipment – model numbers, technical data, calibration data, etc.
   b. Drawings showing the extent of the systems tested.
   c. Test results.
   d. Dates, witnesses, and signatures of witnesses.

B. Testing and Balancing: Test and balance the complete air tempering system as specified in Section 23 0593. It is anticipated that the TAB effort will identify some system deficiencies. Work in a cooperative manner to identify the cause of these deficiencies. Where deficiencies aer due to defects in installation, or workmanship, repair as required and re-test to demonstrate proper performance.

C. Cleaning

1. All ducts, coils, housing, registers, grilles, fans, etc., shall be clean when installed and shall be kept clean until the system is completed. As the various parts of the system are installed, they shall be wiped or blown clean and openings taped dust-tight with heavy paper or cardboard until the system is completed and ready for testing. At that time all covers and protective wrappings shall be removed. Where one has been torn or previously removed, the duct, coil, register, etc., shall be carefully cleaned of any dirt or dust that has entered the opening.

END OF SECTION 23 3000

SECTION 23 3423 - HVAC POWER VENTILATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Utility set fans.
2. Centrifugal roof ventilators.
3. Axial roof ventilators.
4. Centrifugal wall ventilators.
5. In-line centrifugal fans.
6. Propeller fans.

1.3 PERFORMANCE REQUIREMENTS

A. Project Altitude: Base air ratings on actual site elevations.

B. Operating Limits: Classify according to AMCA 99.

1.4 SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:

1. Certified fan performance curves with system operating conditions indicated.
2. Certified fan sound-power ratings.
3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
4. Material gages and finishes, including color charts.
5. Dampers, including housings, linkages, and operators.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.
2. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.

3. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.

C. Coordination Drawings: Show roof penetration requirements and reflected ceiling plans drawn to scale and coordinating roof penetrations and units mounted above ceiling. Show the following:

1. Roof framing and support members relative to duct penetrations.
2. Ceiling suspension assembly members.
3. Size and location of initial access modules for acoustical tile.
4. Ceiling-mounted items including light fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

D. Maintenance Data: For power ventilators to include in maintenance manuals specified in Division 1.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.

C. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

D. UL Standard: Power ventilators shall comply with UL 705.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations, with protective crating and covering.

B. Disassemble and reassemble units, as required for moving to final location, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

1.7 COORDINATION

A. Coordinate size and location of structural-steel support members.

B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3 Section "Cast-in-Place Concrete."

C. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 7 Section "Roof Accessories."

1.8 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Belts: One set for each belt-driven unit.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following, OAE:

1. ACME
2. Cook, Loren Company
3. Penn Ventilation Companies, Inc.
4. Greenheck Fan Corp.

2.2 UTILITY SET FANS

A. Description: Belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, and accessories.

B. Housing: Fabricated of steel with side sheets fastened with a deep lock seam or welded to scroll sheets.

1. Housing Discharge Arrangement: Adjustable to eight standard positions.

C. Fan Wheels: Single-width, single inlet; welded to cast-iron or cast-steel hub and spun-steel inlet cone, with hub keyed to shaft.

1. Blade Materials: Steel.
2. Blade Type: Backward inclined.

D. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.

E. Shaft Bearings: Prelubricated and sealed, self-aligning, pillow-block-type ball bearings with ABMA 9, L_{50} of 200,000 hours.

F. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.

1. Service Factor Based on Fan Motor: 1.5.
2. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with motors larger than 5 hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
3. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
4. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.

G. Accessories:

1. Backdraft Dampers: Gravity actuated with counterweight and interlocking aluminum blades and felt edges in steel frame installed on fan discharge.
2. Access Doors: Gasketed doors with latch-type handles.
3. Scroll Dampers: Single-blade damper installed at fan scroll top with adjustable linkage.
4. Inlet Screens: Removable wire mesh.
5. Drain Connections: NPS 3/4 threaded coupling drain connection installed at lowest point of housing.
6. Weather Hoods: Weather resistant with stamped vents over motor and drive compartment.

2.3 CENTRIFUGAL ROOF VENTILATORS

A. Description: Belt-driven or direct-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.

B. Housing: Removable, galvanized steel, mushroom-domed top; square, one-piece, aluminum base with venturi inlet cone.

C. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.

D. Belt-Driven Drive Assembly: Resiliently mounted to housing, with the following features:

1. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
2. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
3. Pulleys: Cast-iron, adjustable-pitch motor pulley.
4. Fan and motor isolated from exhaust airstream.

E. Accessories:

1. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.
2. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.
3. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.

F. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch- thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to suit roof opening and fan base.

1. Configuration: Self-flashing without a cant strip, with mounting flange.
2. Overall Height: 12 inches.

3. Sound Curb: Curb with sound-absorbing insulation matrix.
4. Pitch Mounting: Manufacture curb for roof slope.
5. Metal Liner: Galvanized steel.
6. Hinged Sub-base: Galvanized steel hinged arrangement permitting service and maintenance.
7. Mounting Pedestal: Galvanized steel with removable access panel.
8. Sound Curb: Curb with sound-absorbing insulation matrix.
9. Pitch Mounting: Manufacture curb for roof slope.
10. Metal Liner: Galvanized steel.
11. Hinged Sub-base: Galvanized steel hinged arrangement permitting service and maintenance.
12. Mounting Pedestal: Galvanized steel with removable access panel.

2.4 CENTRIFUGAL WALL VENTILATORS

A. Description: Belt-driven or direct-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, and accessories.

B. Housing: Heavy-gage, removable, spun-aluminum, dome top and outlet baffle; venturi inlet cone.

C. Fan Wheel: Aluminum hub and wheel with backward-inclined blades.

D. Belt-Driven Drive Assembly: Resiliently mounted to housing, with the following features:

1. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
2. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
3. Pulleys: Cast-iron, adjustable-pitch motor pulley.
4. Fan and motor isolated from exhaust airstream.

E. Accessories:

1. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through internal aluminum conduit.
2. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.
3. Wall Grille: Ring type for flush mounting.
4. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in wall sleeve; factory set to close when fan stops.

2.5 IN-LINE CENTRIFUGAL FANS

A. Description: In-line, belt-driven centrifugal fans consisting of housing, wheel, outlet guide vanes, fan shaft, bearings, motor and disconnect switch, drive assembly, mounting brackets, and accessories.

B. Housing: Split, spun aluminum with aluminum straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.

C. Direct-Driven Units: Motor encased in housing outside of airstream, factory wired to disconnect switch located on outside of fan housing.

D. Belt-Driven Units: Motor mounted on adjustable base, with adjustable sheaves, enclosure around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.

E. Fan Wheels: Aluminum, airfoil blades welded to aluminum hub.

F. Accessories:

1. Companion Flanges: For inlet and outlet duct connections.
2. Fan Guards: 1/2- by 1-inch mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.
3. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.

2.6 PROPELLER FANS

A. Description: Belt-driven or direct-driven propeller fans consisting of fan blades, hub, housing, orifice ring, motor, drive assembly, and accessories.

B. Housing: Galvanized steel sheet with flanged edges and integral orifice ring with baked-enamel finish coat applied after assembly.

C. Steel Fan Wheels: Formed-steel blades riveted to heavy-gage steel spider bolted to cast-iron hub.

D. Fan Wheel: Replaceable, extruded-aluminum, airfoil blades fastened to cast-aluminum hub; factory set pitch angle of blades, may be used.

E. Belt-Driven Drive Assembly: Resiliently mounted to housing, statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.

1. Service Factor Based on Fan Motor: 1.4.
2. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
3. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.

    a. Ball-Bearing Rating Life: ABMA 9, L_{10} of 100,000 hours.

4. Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
5. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with motors larger than 5 hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
6. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
7. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.

F. Accessories:

1. Gravity Shutters: Aluminum blades in aluminum frame; interlocked blades with nylon bearings.

2. Motor-Side Back Guard: Galvanized steel, complying with OSHA specifications, removable for maintenance.
3. Wall Sleeve: Galvanized steel to match fan and accessory size.
4. Weathershield Hood: Galvanized steel to match fan and accessory size.
5. Weathershield Front Guard: Galvanized steel with expanded metal screen.
6. Variable-Speed Controller: Solid-state control to reduce speed from 100 percent to less than 50 percent.
7. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, or on approved surface in sight of fan.

2.7 MOTORS

A. Comply with requirements in Division 23 Section "Motors."

B. Enclosure Type: Guarded dripproof.

2.8 SOURCE QUALITY CONTROL

A. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

B. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install power ventilators level and plumb.

B. Support units using spring isolators having a static deflection of 1 inch. Vibration- and seismic-control devices are specified in Division 23 Sections.

1. Secure vibration and seismic controls to concrete bases using anchor bolts cast in concrete base.

C. Install floor-mounting units on concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 3 Section "Cast-in-Place Concrete."

D. Secure roof-mounting fans to roof curbs with cadmium-plated hardware. Refer to Division 7 Section "Roof Accessories" for installation of roof curbs.

E. Support suspended units from structure using threaded steel rods and spring hangers. Vibration-control devices are specified in Division 23 Sections.

1. In seismic zones, restrain support units.

F. Install units with clearances for service and maintenance.

G. Label units according to requirements specified in Division 23 Section "Mechanical Identification."

3.2 CONNECTIONS

A. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 23 Section "Duct Accessories."

B. Install ducts adjacent to power ventilators to allow service and maintenance.

C. Ground equipment.

D. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.3 FIELD QUALITY CONTROL

A. Equipment Startup Checks:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connection to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Verify that cleaning and adjusting are complete.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
5. Verify lubrication for bearings and other moving parts.
6. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
7. Disable automatic temperature-control operators.
8. Verify that isolation dampers shut tightly when units are "off," and open fully when units are "on."

B. Starting Procedures:

1. Energize motor and adjust fan to indicated rpm.
2. Measure and record motor voltage and amperage.

C. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Remove malfunctioning units, replace with new units, and retest.

D. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

E. Shut unit down and reconnect automatic temperature-control operators.

F. Refer to Division 23 Section "Testing, Adjusting, and Balancing" for testing, adjusting, and balancing procedures.

G. Replace fan and motor pulleys as required to achieve design airflow.

H. Repair or replace malfunctioning units. Retest as specified above after repairs or replacements are made.

3.4 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Lubricate bearings.

3.5 CLEANING

A. On completion of installation, internally clean fans according to manufacturer's written instructions. Remove foreign material and construction debris. Vacuum fan wheel and cabinet.

B. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain power ventilators.

1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules.
2. Review data in maintenance manuals. Refer to Division 1 Section "Closeout Procedures."
3. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
4. Schedule training with Owner, through Architect, with at least seven days' advance notice.

END OF SECTION 23 3423

SECTION 23 3713 - DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes ceiling- and wall-mounted diffusers, registers, and grilles.

B. Related Sections include the following:

1. Division 23 Section 23 3000 "Air Tempering System and Equipment" for fire and smoke dampers and volume-control dampers not integral to diffusers, registers, and grilles.
2. See special notes and requirements on Division 23 Drawings.

1.3 SUBMITTALS

A. Product Data: For each product indicated, include the following:

1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
2. Diffuser, Register, and Grille Schedule: Indicate Drawing designation, room location, quantity, model number, size, and accessories furnished.

B. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Ceiling suspension assembly members.
2. Method of attaching hangers to building structure.
3. Size and location of initial access modules for acoustical tile.
4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
5. Duct access panels.

C. Samples for Initial Selection: For diffusers, registers, and grilles with factory-applied color finishes.

D. Samples for Verification: For diffusers, registers, and grilles, in manufacturer's standard sizes to verify color selected.

PART 2 - PRODUCTS

2.1 GENERAL

A. Grilles, registers and diffusers shall be fabricated of steel or aluminum. Aluminum only shall be used in areas of high moisture content. Steel grilles, diffusers and registers shall receive a zinc phosphate prime coat and a baked white enamel finish. Aluminum grilles, diffusers and registers shall also be finished in baked white enamel. The type of grille, diffuser, or register is shown by symbol number on the drawings. All symbol numbers shall be crosschecked against the architectural room finish schedule, which shall govern in the event of conflict; discrepancies shall be clearly noted on the submittals. Furnish additional T-bars as required to support and finish around ceiling mounted diffusers and grilles. Equipment manufactured by Metalaire, Krueger, or Titus. Ductwork runouts connecting diffusers with round necks shall be the same size as the diffuser neck, unless otherwise noted. All grilles, registers and diffusers shall be ADC (Air Diffusion Council) certified and rated in accordance with the ADC equipment test code.

2.2 DIFFUSERS, GRILLES AND REGISTERS

- DVD-1 Description: Furnish and install Price model series DF1R (WxH) (or approved equal) with the configurations and mounting types indicated on the plans and air outlet schedule.

- Performance: Air shall be delivered to the space at low noise levels and low velocities that are even across the diffuser face, in all ducting configurations and without the use of nozzles. Diffuser Manufacturer shall provide sound and pressure drop data derived from tests in accordance with ASHRAE Standard 70-2006.Performance data for Draft Rate (%DR) shall be provided based on tests in accordance with ASHRAE Standard 55-2004. A software program that allows room comfort evaluation for specific operating conditions and diffuser locations shall be available to aid in performance assessment. If such a computer program is not available from the manufacturer, the manufacturer shall supply, free of charge, a CFD model of the representative spaces completed by a modeling contractor who has demonstrable qualifications to model such spaces. These shall include no less than 10 years of experience in the modeling of displacement ventilation systems, thorough validation of the code through comparison to empirical data as well as a list of references.

- Construction: The 1-way flat faced recessed displacement diffuser, model DF1R, shall be constructed with an equalization baffle behind the operative diffuser face for uniform, low velocity, distribution of supply air. Both the equalization baffle and face shall be securely retained in the diffuser frames. Plastic nozzle arrays or any plastic components are unacceptable. There shall be no visible fasteners on the front panel. The operative face shall be constructed of painted 16 gauge perforated steel. The installation frame shall be constructed of 24 gage steel. The internal baffling elements shall be constructed of aluminum. The paint shall be powder coat polyester. Epoxies and their derivatives are unacceptable. Visible non-metallic components are unacceptable. The diffuser shall be supplied with an installation frame for recessed installation that is not visible from the room. (The diffuser shall be supplied with an installation frame for recessed installation which allows the diffuser to be installed in areas where plaster is required).

- E. Mounting/Fastening: The diffuser shall be installed within the supplied installation frame. The diffuser shall have no visible fasteners or framing, and shall be held within the supplied installation frame via secure mounting clips.

- DVD-2 Description: Furnish and install Price model series DF1 (WxH) (or approved equal) with the configurations and mounting types indicated on the plans and air outlet schedule.

- Performance: Air shall be delivered to the space at low noise levels and low velocities that are even across the diffuser face, in all ducting configurations and without the use of nozzles. Diffuser Manufacturer shall provide sound and pressure drop data derived from tests in accordance with ASHRAE Standard 70-2006.Performance data for Draft Rate (%DR) shall be provided based on tests in accordance with ASHRAE Standard 55-2004. A software program that allows room comfort evaluation for specific operating conditions and diffuser locations shall be available to aid in performance assessment. If such a computer program is not available from the manufacturer, the manufacturer shall supply, free of charge, a CFD model of the representative spaces completed by a modeling contractor who has demonstrable qualifications to model such spaces. These shall include no less than 10 years of experience in the modeling of displacement ventilation systems, thorough validation of the code through comparison to empirical data as well as a list of references.

- Construction: The 1 way flat faced Displacement diffuser, model DF1 shall be constructed with an equalization baffle behind the operative diffuser face for uniform, low velocity, distribution of supply air. Both the equalization baffle and face shall be securely retained in the diffuser frames. Plastic nozzle arrays or any plastic components are unacceptable. The diffuser frames shall be constructed of high strength aluminum extrusion for rigidity and protection of the operative face and side panels. There shall be no visible fasteners on the front or side panels. The operative face shall be constructed of painted 16 gauge perforated steel, rear side and end panels shall beprovided in painted 20 gauge steel. The frame andinternal baffling elements shall be constructed ofAluminum. The diffuser shall be available for ductconnection at the top, bottom, side or rear of the diffuser with a factory or field cut inlet. The paint shallbe powder coat polyester. Epoxies and their derivatives are unacceptable. Visible non-metallic componentsare unacceptable. The diffuser shall be supplied with a rail mounting system that does not requirepuncturing the diffuser to install. Mounting/Fastening: The diffuser shall fasten to the wall via a rail mounting system. The rail mounting system with metal cover strips to conceal all visible fasteners.

- SD-1 Ceiling Supply Diffuser: Stamped face, Lay-in ceiling, round neck with adjustable tabs, fixed louvers, and baked white enamel finish. Price SCD or equivalent. T-Bar mount, SCD, Type 3.

- SD-2 Ceiling Supply Diffuser: Stamped face, fixed ceiling, round neck with adjustable tabs, fixed louvers, volume regulator, baked white enamel finish. Price SCD, or equivalent. Surface mount, SCD, Type 31.

- SD-3 Ceiling Supply Diffuser: Stamped face, Lay-in ceiling, round neck with adjustable tabs, fixed louvers, and baked white enamel finish. Price SCD or equivalent. T-Bar mount, SCD, Type 3.

- SD-4 Ceiling Supply Diffuser: Stamped face, fixed ceiling, round neck with adjustable tabs, fixed louvers, volume regulator, baked white enamel finish. Price SCD, or equivalent. Surface mount, SCD, Type 31.

- SR-1 Sidewall Supply Register: Double deflection type with horizontal face bars and opposed blade damper with removable key operator, 1-1/4" flat margin, 3/4" bar spacing, baked white enamel finish, aluminum or steel, and sized as shown on the drawings. Price 520D, or equivalent.

- EG-1 Ceiling Exhaust Register: Aluminum core of 1/2" x 1/2" x 1/2" squares in 3/16" aluminum or steel frame for use in exposed tee bar ceiling with white aluminum finish, sized as shown on the drawings. Price 80, or equivalent.

- EG-2 Ceiling Exhaust Register: Aluminum core of 1/2" x 1/2" x 1/2" squares in flat aluminum frame with approximately 1-1/2" margin for surface mounting with white aluminum finish, and opposed blade damper. Sized as shown on drawings. Price 80D with damper, or equivalent.

- ER-1 Sidewall Exhaust Register: Fixed horizontal bars on 3/4" centers set at 45 degrees, approximately 1-1/4" margin, opposed blade damper, baked white enamel finish, and sized as shown on the drawings. Price 530D, or equivalent.

- RG-1 Ceiling Return Grille: Aluminum core of 1/2" x 1/2" x 1/2" squares in flat aluminum frame with approximately 1-1/4" margin for surface or lay-in mounting. Sized as shown on drawings. Price 80 or equivalent.

- RR-1 Sidewall Return Air or Transfer Grille: Fixed horizontal bars on 3/4" centers set at 45 degrees, approximately 1-1/4" margin, no opposed blade damper, baked white enamel finish, furnish grille on each exposed wall surface, and sized as shown on the drawings. Price 530, or equivalent.

- SS-1 Linear Supply Diffuser: Extruded aluminum construction with baked white enamel frame suitable for lay-in or surface mounting to gypboard (ceiling and sidewall). Surface mounted type shall have minimum 1-1/8" borders with frame mounting holes. Interior surfaces shall be finished in dull black. Diffusers shall have a fully adjustable air pattern with flow control vanes that shall be capable of deflecting the air pattern from horizontal to vertical or at intermediate settings. Each diffuser shall have a self-aligning device (where length is greater than four feet) resulting in perfect alignment without being visible. See plans for actual cfm, diffuser length, type of ceiling, and number of 1" slots. Price SDA100 or equivalent. Provide linear slot sheet metal plenum.

- RS-1 Linear Return: Extruded aluminum construction with baked white enamel frame suitable for lay-in or surface mounting to gypboard (ceiling and sidewall). Surface mounted type shall have minimum 1-1/8" borders with frame mounting holes. Interior surfaces shall be finished in dull black. Each linear return shall have a self-aligning device (where length is greater than four feet) resulting in perfect alignment without being visible. See schedule and plans for actual cfm, for length, type of ceiling, and number of 1" slots. Price SDR-8 SLOT or equivalent.

2.3 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install diffusers, registers, and grilles level and plumb.

B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practicable. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.3 ADJUSTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 23 3713

SECTION 23 3813 - KITCHEN EXHAUST AND MAKEUP AIR SYSTEMS

PART 1 - GENERAL

1.1 REQUIREMENTS

A. Conform to applicable provisions of the General Conditions, Special Conditions and General Requirements.

B. Comply with all requirements specified in Section 23 30 00, and see that section for components and installation requirements not specified in this Section.

C. See also Sections 23 0500, 23 0548, 23 0549, 23 0593, 23 0700, and 23 0900 for related work.

1.2 SCOPE

A. Provide all equipment, sheetmetal, and HVAC system components indicated on the drawings and specified herein for complete and functional HVAC systems to serve the kitchen. This section includes those components that are unique to the kitchen makeup and exhaust air systems. Certain components are specified in Section 23 30 00.

B. Rough-in and connect to kitchen hoods supplied and/or installed by others.

1.3 SUBMITTALS

A. Submit the following for review and approval:

1. All equipment shown on the equipment schedule and/or specified herein.
2. Ductwork construction standards, accessories, and layouts. Layouts shall be at a scale appropriate for the areas shown, but not less than 3/8-inch = 1’-0”. Include large scale sections as appropriate.

1.4 QUALITY ASSURANCE

A. Comply with UMC-2006 Chapter 5 Articles 5.07 through 5.17.

B. Comply with NFPA-96.

C. Fire extinguishing systems shall be installed by persons trained and qualified to install the specific system provided.

1.5 DEFINITIONS

A. Type 1 Hood: A kitchen hood for collecting and removing grease and smoke.

B. Type 2 Hood: A kitchen hood for collecting and removing steam, vapors, heat or odors.

PART 2 - PRODUCTS

2.1 MAKEUP AIR UNITS

A. Rooftop Direct-Fired/Evap Cooled

1. General: Factory fabricated, packaged rooftop, direct-fired with evap cooling, ETL Listed to ASNI Z83.4-1999, factory wired and tested (gas train, electrical components and air flow controls).
2. Unit Construction: Heavy gauge G90 galvanized steel casing with corrosion resistant fasteners, weatherproof with standing seam where roof panels are joined, all metal-to-metal surfaces sealed where exposed to the weather, 1-inch fiberglass insulation, discharge configuration as indicated on drawings, access doors or removable panels for ready access to all components, and lifting lugs.
3. Heating Section: Direct fired with cast aluminum burner, for use with natural gas at 900 – 1000 Btu/SCF HHV, SS mixing plates, Maxitrol or equivalent controls with 25:1 turndown, IRI or FM gas train, and all necessary safety and operating controls..
4. Cooling Section: Evaporative type, SS module construction, 12-inch media with 90% cooling effectiveness, with float-type makeup, 120V pump with discharge piping and corrosion-resistant distribution header, drain & overflow connections.
5. Fan Section: AMCA rated for both performance and sound, centrifugal type statically and dynamically balanced, permanently lubricated bearings with 100,000 Hr L-10 life at maximum cataloged speed, belt driven with drive sized for 150% of motor HP, pulleys with machined surfaces, adjustable sheaves for 15 Hp and less, motor per Spec Section 23 05 00, fan discharge flexible connection, and with fan and motor mounted on common base.
6. Electrical and Controls: Factory wired for service from a single-point power connection, with all necessary power and control components mounted in accessible and weather-protected enclosures, all wiring per the NEC, control transformer with secondary fusing, contacts for remote start/stop and monitoring of fan status, and discharge temperature sensor with all components necessary for discharge temperature control. All components UL listed, recognized or classified where applicable.
7. Accessories: double wall construction, motorized intake damper, 2-inch aluminum mesh filters sized for less than 550 FPM, dirty filter switch, fan and motor base spring isolated with minimum 1-inch static deflection, discharge fan configuration as shown on drawings, inlet weather hood with bird screen, louvered inlet with bird screen, minimum 12-inch insulated roof curb of G90 galvanized steel, evaporative cooler media with Class II rating per UL 900 (e.g., GLASdek), automatic blowdown controls (timed blowdown is acceptable), disconnect switch, fan motor starter, premium efficiency motor, and 115V convenience receptacle in NEMA 3R enclosure.

    a. Variable Volume: Class F motor insulation and automatic burner bypass damper (may be self-adjusting) to ensure proper burner operation under the full range of operating conditions.

8. Approved Manufacturers: Captive Aire, Greenheck Model DGX, Spec Air, or approved equal.

2.2 EXHAUST FANS

A. Centrifugal Roof Exhaust Type:

1. Factory fabricated fan, motor, drive, and accessories specifically designed for kitchen hood exhaust applications. Leakproof construction, listed for grease removal per UL 762, with air and sound data listed per

a. Housing: Spun aluminum construction, vertical discharge, reinforced wind band welded to one-piece curb cap with mounting holes on the side and integral spun venturi, spun aluminum motor compartment with readily removable cover and breather tube. All other structural components shall be galvanized steel.
b. Fan wheel: Backward inclined, centrifugal, non-overloading, statically & dynamically balanced, with shaft sized so first critical speed is minimum 25% above maximum operating speed.
c. Motor and drive: Premium efficiency ODP motor per Spec Section 23 05 00, out of the air stream, cooled with ambient air, direct drive or belt driven as indicated in schedule on drawings, bearings with 100,000 hr L-10 life. Motor, drive and fan wheel resiliently mounted on neoprene isolators.
1) Variable Speed Applications: Provide Class F insulation.

d. Belt Drive: Adjustable pitch sheave up to 5 Hp, fixed pitch above this HP, cast and machined pulleys with all components sized for 150% of motor Hp.
e. Electrical: Disconnect (NEMA-1 if protected from the weather, or NEMA-3R if exposed to the weather) wired to motor, with all wiring and components per NEC and either UL Listed or UL recognized.
f. Accessories: Stamped aluminum nameplate, hinge kit to allow tilting fan up to inspect wheel, retaining chains, grease trap with absorbent material, drain trough which can be piped either to a roof-mounted grease collector, or can be piped back to the hood, conduit chase and roof curb.

1) Roof Curb: Minimum 24-inch galvanized steel, fiberglass insulated, with wood nailer, and flange. Provide cant and step if needed for proper seal with roof. Provide ventilated extension curb so exhaust duct extends minimum 18-inches above roof deck, and so fan discharges minimum 40-inches above roof deck.

g. Approved Manufacturers: Greenheck CUE or CUBE, Cook, or approved equal.

2.3 DUCTWORK

A. Makeup Air System: Galvanized steel per Section 23 3000.

B. Type 1 Hood Exhaust Systems

1. Ductwork and Supports: Minimum 16-gauge carbon steel or 18-guage SS.
2. Access Panels: Minimum 16 gauge steel with latching mechanism or bolted door fasteners, grease-tight, UL Listed for installation into grease duct, with temperature

resistant gasket and sealant. Acudor, Flame Guard, or equal.

3. Alternate: A UL Listed, double wall grease duct system may be used in lieu of a welded system as specified here. All fittings and joints shall be supplied by the Manufacturer. Provide all necessary cleanouts, drains, etc. Approved manufacturers: Metal Fab, Metalbestos Schebler, DAE.

C. Stainless Steel Ductwork: Provided 304 SS ductwork for moisture-laden exhaust air streams (e.g., dishwashers) 18 gauge No. 2B finish where ducts are exposed, with continuously welded joints, liquid-tight. Where seams are located on bottom surface or within 1.5-inches of bottom surface, continuously weld seams liquid-tight.

PART 3 - EXECUTION

3.1 MAKEUP AIR UNITS

A. Install roof curb as per Spec Section 23 30 00 and install MAU onto curb. Install gas piping, water and drainage piping, discharge ductwork, and controls.

B. Start up unit. Have manufacturer's representative confirm proper system operation and submit startup report.

C. Demonstrate proper system operation to the owner's representative, including:

1. That MAU and exhaust fans energize together based on kitchen hood switch.
2. That motorized isolation damper opens when unit is energized and shuts when unit is off.
3. That discharge temperature controls properly modulate heating control and cycle evaporative cooler pump to maintain discharge temperature setpoint
4. That evaporative cooler makeup and blowdown systems function properly
5. That evaporative cooler shutoff valve and drain valve are conveniently located along a wall approximately 5 ft above grade, and that all piping subject to freezing can be readily and completely drained into a floor drain or floor sink to prevent freezing, without draining onto the floor.

3.2 EXHAUST FANS

A. Install roof curb as per Spec Section 23 30 00, and install fan onto curb. Connect ductwork per fan manufacturer's recommendations and per UMC Section 511.

3.3 DUCTWORK

A. General:

1. Comply with the requirements specified in Section 23 30 00 and UMC Sections 507 – 517.
2. Install without forming dips or traps which might collect residue
3. Lowest end of main duct shall be flush on the bottom with branch duct.

B. Exhaust Ductwork for Type I Hoods

1. Install ductwork, insulation, grease removal devices, fans, etc, so as to maintain required clearances from adjacent construction.
2. Materials and Thicknesses:

    a. Interior Ductwork: 16-gauge steel or 18-gauge SS
    b. Exterior Ductwork: 18 gauge SS

3. Construction:

    a. All seams, joints, penetrations, duct-to-hood collar connections, etc, shall be continuously welded and liquid-tight except as permitted by UMC Section 510.5.2.1.
    b. Install so that grease cannot become pocketed in any portion of ductwork.
    c. Telescoping or bell-type duct joints: Configure to be self-draining and per UMC Section 510.5.2.2.
    d. Slope: Minimum 1/4 inch per foot to drain toward hood or approved grease reservoir. Where horizontal length exceeds 75 ft, slope not less than 1 inch per ft.
    e. Bolts, screws, rivets and other mechanical fasteners: Shall not penetrate duct walls.

4. Dampers and flexible connectors: Do not provide in Type 1 hood exhaust systems.
5. UL Listed Grease Duct Systems: Install in accordance with their listing, and per manufacturer's recommendations.
6. Openings:

    a. Provide as required to allow proper operation, maintenance, inspection and cleaning of all sections of ductwork, and as required by code.
    b. Provide at each change in direction.
    c. Locate so as to provide unobstructed access to openings. Provide a sign on each access panel reading, "ACCESS PANEL – DO NOT OBSTRUCT".
    d. Provide within 3 ft of fan inlet and outlet where fans have ducted connections.
    e. Horizontal Ducts:

        1) Provide openings large enough for cleaning. Locate not more than 12 ft on centers.
        2) Where any duct crossectional dimension is 24-inches or larger, provide minimum one 20-inch x 20-inch opening for personnel entry. Provide hangers to support the weight of ductwork plus 800 lbs.
        3) Install on sides or top of duct, minimum 1-1/2 inch from the bottom of the duct.

    f. Vertical Ducts:

        1) Where personnel entry is possible provide access door at top of riser
        2) Where personnel entry is not possible, provide access door at each floor level.

7. Supports: Provide as required to support vertical and lateral loads within the stress limitations of the building code. Supports shall be of the same material as the ductwork.
8. Damage to Covering or Enclosure: Advise Owner's Representative if any portion of ductwork, insulation or ductwork enclosure is damaged in any way, and repair so as to restore fire-resistance rating.

C. Exhaust Ductwork for Wet Applications:

1. Provide 18-gauge 304 SS ductwork for moisture-laden exhaust air streams (e.g., dishwashers) with No. 2B finish where ducts are exposed, with continuously welded joints, liquid-tight. Where seams are located on bottom surface or within 1.5-inches of bottom surface, continuously weld seams liquid-tight.
2. Welds shall be free from pits, runs, spatter and other imperfections, and ground smooth and flush with joined surfaces. Pitch horizontal ductwork downward toward intake opening. Where traps occur that collect water, provide a 3/4-inch half-coupling welded to the bottom of the duct and extended to the nearest drain.

D. Exhaust Ductwork for Type 2 Hoods in Dry Applications: Galvanized steel per Spec Section 23 3000.

3.4 CLEANING

A. Clean ductwork per Specification Section 23 3000.

END OF SECTION 23 3813

SECTION 23 5216 - CONDENSING BOILERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes packaged, factory-fabricated and -assembled, gas-fired, fire-tube condensing boilers, trim, and accessories for generating.

1.3 ACTION SUBMITTALS

A. Product Data: Include performance data, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: For boilers, boiler trim, and accessories. Include plans, elevations, sections, details, and attachments to other work.

1. Design calculations and vibration isolation base details, signed and sealed by a qualified professional engineer.

a. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
b. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails and equipment mounting frames.

2. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Manufacturer Seismic Qualification Certification: Submit certification that boiler, accessories, and components will withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Source quality-control reports.

C. Field quality-control reports.

D. Warranty: Special warranty specified in this Section.

E. Other Informational Submittals:

1. ASME Stamp Certification and Report: Submit "A," "S," or "PP" stamp certificate of authorization, as required by authorities having jurisdiction, and document hydrostatic testing of piping external to boiler.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For boilers to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. ASME Compliance: Fabricate and label boilers to comply with ASME Boiler and Pressure Vessel Code.

C. ASHRAE/IESNA 90.1 Compliance: Boilers shall have minimum efficiency according to "Gas and Oil Fired Boilers - Minimum Efficiency Requirements."

D. DOE Compliance: Minimum efficiency shall comply with 10 CFR 430, Subpart B, Appendix N, "Uniform Test Method for Measuring the Energy Consumption of Furnaces and Boilers."

E. UL Compliance: Test boilers for compliance with UL 795, "Commercial-Industrial Gas Heating Equipment." Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

1.7 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of boilers that fails in materials or workmanship within specified warranty period.

1. Warranty Period for Fire-Tube Condensing Boilers:

a. Leakage and Materials: ten <10> years from date of Substantial Completion.
b. Heat Exchanger Damaged by Thermal Stress and Corrosion: Prorated for ten <10> years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 FIRE-TUBE CONDENSING BOILERS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Lochinvar or approved equal.

B. Description: Factory-fabricated, -assembled, and -tested, fire-tube condensing boiler with heat exchanger sealed pressure tight, built on a steel base; including insulated jacket; flue-gas vent; combustion-air intake connections; water supply, return, and condensate drain connections; and controls. Water heating service only.

C. Hot water boilers and associated auxiliary equipment shall be as specified on the equipment schedule on the drawings.

D. The Contractor shall furnish and install a factory assembled automatic boiler control system as specified on the Equipment Schedule on the drawings and in Section 230900 for fully automatic operation of the boiler system. Electrical power, control, and interlock wiring shall be provided as specified in Section 23 0500 and 23 0549 and Division 26, Electrical.

E. Furnish and install all devices as requested by the City of Farmington boiler inspector. Local manufacturer's representative must have minimum five (5) years experience in startup and service of boiler to be provided.

F. The BOILER shall bear the ASME "H" stamp for 160 psi working pressure and shall be National Board listed. The BOILER shall have a fully welded 316L stainless steel, fire tube heat exchanger. There shall be a single pressure vessel. Multiple pressure vessels are not acceptable. Fire Tube shall be of the Wave Fire Tube design and capable of transferring 30,000 to 40,000 Btu’s per tube. A liquid impact die shall be used to form the Wave Fire Tube. There shall be no banding material, bolts, gaskets or "O" rings in the heat exchanger construction. The Wave Fire Tube shall be robotically welded to the tube sheets. The heat exchanger shall be designed for a single-pass water flow to limit the water side pressure drop. Pressure drop shall

be no greater than 2.4 psi at 180 gpm. The condensate collection basin shall be constructed of welded 316L stainless steel. The complete heat exchanger assembly shall carry a ten (10) year limited warranty.

G. The BOILER shall be certified and listed by C.S.A. International under the latest edition of the harmonized ANSI Z21.13 test standard for the U.S. and Canada. The BOILER shall comply with the energy efficiency requirements of the latest edition of the ASHRAE 90.1 Standard and the minimum efficiency requirements of the latest edition of the AHRI BTS-2000 Standard as defined by the Department of Energy in 10 CFR Part 431. The BOILER shall operate at a minimum of 92% thermal efficiency (FB 1500- FB 3500) or 93% thermal efficiency (FB 4000-FB 5000) at full fire as registered with AHRI. All models shall operate up to 97% thermal efficiency with return water temperatures at 90°F or below at 20°F temperature rise. The BOILER shall be certified for indoor installation.

H. The BOILER shall be constructed with a heavy gauge steel jacket assembly, primed and pre-painted on both sides. The combustion chamber shall be sealed and completely enclosed, independent of the outer jacket assembly, so that integrity of the outer jacket does not affect a proper seal. Two burner/flame observation ports shall be provided. The single burner shall be a premix design with an upper and a lower chamber supplied by individual combustion systems and constructed of high temperature stainless steel with a woven Fecralloy outer covering to provide modulating firing rates. The BOILER shall be supplied with two gas valves designed with negative pressure regulation and be equipped with a pulse width modulation blower system, to precisely control the fuel/air mixture to provide modulating boiler firing rates for maximum efficiency. The BOILER shall operate in a safe condition with gas supply pressures as low as 4 inches of water column. The burner flame shall be ignited by direct spark ignition with flame monitoring via a flame sensor.

I. The BOILER shall utilize a 24 VAC control circuit and components. The control system shall have a display for boiler set-up, boiler status, and boiler diagnostics. All components shall be easily accessed and serviceable from the front and top of the jacket. The BOILER shall be equipped with a temperature/pressure gauge; high limit temperature control with manual reset; ASME certified pressure relief valve set for 50 psi (standard); outlet water temperature sensor (dual thermistor); return water temperature sensor; outdoor air sensor, flue temperature sensor (dual thermistor); high and low gas pressure switches, low water cut off with manual reset, blocked drain switch and a condensate trap for the heat exchanger condensate drain.

J. The BOILER shall feature the "SMART TOUCH™" control which is standard and factory installed with an 8" liquid crystal touch screen display, password security, outdoor air reset, pump delay with freeze protection, pump exercise, ramp delay featuring six steps, domestic hot water prioritization with limiting capabilities and PC port connection. A secondary control that is field mounted outside or inside the appliance is not acceptable. The BOILER shall have alarm contacts for any failure, runtime contacts and data logging of runtime at given modulation rates, ignition attempts and ignition failures. The BOILER shall have a built-in "Cascade" to sequence and rotate while maintaining modulation of up to eight boilers of different Btu inputs without utilization of an external controller. The internal "Cascade" function shall be capable of lead-lag, efficiency optimization, front-end loading, and rotation of lead boiler every 24 hours. The BOILER shall be capable of controlling an isolation valve (valve shall be offered by manufacturer) during heating operation and rotation of open valves in standby operation for full flow applications. The control must be equipped with standard Modbus communication protocol with a minimum 55 readable points. The BOILER shall have an optional gateway device which will allow integration with LON or BacNet (MSTP or IP) protocols.

K. The “SMART TOUCH™” control shall increase fan speed to boost flame signal when a weak flame signal is detected during normal operation. A 0 -10 VDC output signal shall control a variable speed boiler pump (pump to be offered by manufacturer) to keep a fixed delta t across the boiler regardless of the modulation rate. The BOILER shall have the capability to receive a 0 – 10 VDC input signal from a variable speed system pump to anticipate changes in system heat load in order to prevent flow related issues such as erratic temperature cycling.

L. The BOILER shall be equipped with two terminal strips for electrical connection. A low voltage connection board with 30 data points for safety and operating controls, i.e., Alarm Contacts, Runtime Contacts, Louver Proving Switch, Tank Thermostat, Remote Enable/Disable, System Supply Sensor, Outdoor Sensor, Tank Sensor, Modbus Building Management System signal and Cascade control circuit. A high voltage terminal strip shall be provided for Supply voltage. Supply voltage shall be 120 volt / 60 hertz / single phase on models up to 3,500,000 Btu’s/Hr. Models 4,000,000 Btu’s/Hr. and up shall be 208 volt / 60 hertz / three phase. The boiler may be factory trimmed for optional supply voltages, i.e. 208 volt / 60 hertz / 3 phase, 480 volt / 60 hertz / 3 phase and 600 volt / 60 hertz / 3 phase. The high voltage terminal strip plus integral relays are provided for independent pump control of the System pump, the Boiler pump and the Domestic Hot Water pump.

M. Direct Vent system with vertical and sidewall termination of both the exhaust vent and combustion air. The flue shall be Category IV approved Stainless Steel sealed vent material terminating at the rooftop with the manufacturer’s specified vent termination. A separate pipe shall supply combustion air directly to the boiler from the outside. The air inlet pipe must be sealed and may be other materials listed in the Installation manual. The boiler’s total combined air intake length shall not exceed 100 equivalent feet. The boiler’s total combined exhaust venting length shall not exceed 100 equivalent feet. The air inlet must terminate on the rooftop with the exhaust.

N. The BOILER shall have an independent laboratory rating for Oxides of Nitrogen (NOx) to meet the requirements of South Coast Air Quality Management District in Southern California and the requirements of Texas Commission on Environmental Quality (FB 1500-FB 2000). The manufacturer shall verify proper operation of the burner, all controls and the heat exchanger by connection to water and venting for a factory fire test prior to shipping.

O. The BOILER shall operate at altitudes up to 4,500 feet above sea level without additional parts or adjustments. High altitude operation shall be certified at a minimum of 4,500 feet above sea level by a 3rd party organization.

P. Characteristics and Capacities:

1. See Schedule.

2.2 TRIM

A. Include devices sized to comply with ANSI B31.9, "Building Services Piping."

B. Aquastat Controllers: Operating, firing rate, and high limit.

C. Safety Relief Valve: ASME rated.

D. Pressure and Temperature Gage: Minimum 3-1/2-inch- (89-mm-) diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges so normal operating range is about 50 percent of full range.

E. Boiler Air Vent: Automatic.

F. Drain Valve: Minimum NPS 3/4 (DN 20) hose-end gate valve.

G. Circulation Pump: Non-overloading, in-line pump with split-capacitor motor having thermal-overload protection and lubricated bearings; designed to operate at specified boiler pressures and temperatures.

2.3 CONTROLS

A. Refer to Section 230900 "Instrumentation and Control for HVAC."

B. Boiler operating controls shall include the following devices and features:

1. Control transformer.
2. Set-Point Adjust: Set points shall be adjustable.
3. Operating Pressure Control: Factory wired and mounted to cycle burner.
4. Low-Water Cutoff and Pump Control: Cycle feedwater pump(s) for makeup water control.
5. High Cutoff: [Manual] [Automatic] reset stops burner if operating conditions rise above maximum boiler design [temperature] [pressure].
6. Low-Water Cutoff Switch: [Electronic] [Float and electronic] probe shall prevent burner operation on low water. Cutoff switch shall be [manual] [automatic]-reset type.
7. Blocked Inlet Safety Switch: Manual-reset pressure switch field mounted on boiler combustion-air inlet.
8. Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.

C. Building Automation System Interface: Factory install hardware and software to enable building automation system to monitor, control, and display boiler status and alarms.

1. A communication interface with building automation system shall enable building automation system operator to remotely control and monitor the boiler from an operator workstation. Control features available, and monitoring points displayed, locally at boiler control panel shall be available through building automation system.

2.4 ELECTRICAL POWER

A. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in electrical Sections.

B. Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.

1. House in NEMA 250, Type 1 enclosure.
2. Wiring shall be numbered and color-coded to match wiring diagram.
3. Install factory wiring outside of an enclosure in a metal raceway.
4. Provide branch power circuit to each motor and to controls with a disconnect switch or circuit breaker.
5. Provide each motor with overcurrent protection.

2.5 VENTING KITS

A. Kit: Complete system, ASTM A 959, Type 29-4C stainless steel, pipe, vent terminal, thimble, indoor plate, vent adapter, condensate trap and dilution tank, and sealant.

B. Combustion-Air Intake: Complete system, stainless steel, pipe, vent terminal with screen, inlet air coupling, and sealant.

2.6 SOURCE QUALITY CONTROL

A. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.

B. Test and inspect factory-assembled boilers, before shipping, according to ASME Boiler and Pressure Vessel Code.

C. Allow Owner access to source quality-control testing of boilers. Notify Architect 14 days in advance of testing.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Before boiler installation, examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting boiler performance, maintenance, and operations.

1. Final boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

B. Examine mechanical spaces for suitable conditions where boilers will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 BOILER INSTALLATION

A. Equipment Mounting:

1. Install boilers on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

B. Install gas-fired boilers according to NFPA 54.

C. Assemble and install boiler trim.

D. Install electrical devices furnished with boiler but not specified to be factory mounted.

E. Install control wiring to field-mounted electrical devices.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to boiler to allow service and maintenance.

C. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.

D. Connect piping to boilers, except safety relief valve connections, with flexible connectors of materials suitable for service. Flexible connectors and their installation are specified in Section 232116 Hydronic Piping Specialties."

E. Connect gas piping to boiler gas-train inlet with union. Piping shall be at least full size of gas train connection. Provide a reducer if required.

F. Connect hot-water piping to supply- and return-boiler tappings with shutoff valve and union or flange at each connection.

G. Install piping from safety relief valves to nearest floor drain.

H. Boiler Venting:

1. Install flue venting kit and combustion-air intake.
2. Connect full size to boiler connections.

I. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

J. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Perform installation and startup checks according to manufacturer's written instructions.
2. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

    a. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level and water temperature.
    b. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

D. Remove and replace malfunctioning units and retest as specified above.

E. Prepare test and inspection reports.

F. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.

G. Performance Tests:

1. Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct performance testing.
2. Boilers shall comply with performance requirements indicated, as determined by field performance tests. Adjust, modify, or replace equipment to comply.
3. Perform field performance tests to determine capacity and efficiency of boilers.

    a. Test for full capacity.
    b. Test for boiler efficiency at low fire 20, 40, 60, 80, 100, 80, 60, 40, and 20 percent of full capacity. Determine efficiency at each test point.

4. Repeat tests until results comply with requirements indicated.
5. Provide analysis equipment required to determine performance.
6. Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are not adequate.
7. Notify Architect in advance of test dates.
8. Document test results in a report and submit to Architect.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain boilers. Refer to Section 017900 "Demonstration and Training."

END OF SECTION 23 5216

SECTION 23 7313 - MODULAR INDOOR CENTRAL-STATION AIR-HANDLING UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 RELATED SECTIONS

A. Section 23 0500, Common Work Requirements for HVAC.

B. Section 23 0504, Pipe and Pipe Fittings.

C. Section 23 0505, Piping Specialties.

D. Section 23 0523, Valves.

E. Section 23 0700, HVAC Insulation.

F. Section 23 0900, Facility Management System, for temperature control valves, meters and instrumentation.

G. Division 26, Electrical.

1.3 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design vibration isolation and seismic-restraint details, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Structural Performance: Casing panels shall be self-supporting and capable of withstanding 133 percent of internal static pressures indicated, without panel joints exceeding a deflection of L/100 where "L" is the unsupported span length within completed casings.

C. Seismic Performance: Air-handling units shall withstand the effects of earthquake motions determined according to ASCE/SEI.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Mechanical-room layout and relationships between components and adjacent structural and mechanical elements.
2. Support location, type, and weight.
3. Field measurements.

B. Seismic Qualification Certificates: For air-handling units, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Source quality-control reports.

D. Field quality-control reports.

1.5 ACTION SUBMITTALS

A. Product Data: For each air-handling unit indicated.

1. Unit dimensions and weight.
2. Cabinet material, metal thickness, finishes, insulation, and accessories.
3. Fans:

    a. Certified fan-performance curves with system operating conditions indicated.
    b. Certified fan-sound power ratings.
    c. Fan construction and accessories.
    d. Motor ratings, electrical characteristics, and motor accessories.

4. Certified coil-performance ratings with system operating conditions indicated.
5. Dampers, including housings, linkages, and operators.
6. Filters with performance characteristics.
7. AHU manufacturer shall provide the following information with each shop drawing/product data submission:
8. Dimensioned arrangement drawings for each AHU including a plan and elevation view of the assembled unit with overall dimensions, lift points, unit shipping split locations and dimensions, installation and operating weights, and installation, operation and service clearances.
9. All electrical, piping, and ductwork requirements, including sizes, connection locations, and connection method recommendations.

10. Each component of the unit shall be identified and mechanical specifications shall be provided for unit and accessories describing construction, components, and options.
11. All performance data, including capacities and airside and waterside pressure drops, for components.
12. Fan curves shall be provided for fans with the design operating points indicated. Data shall be corrected to actual operating conditions, temperatures, and altitudes.
13. For units with multiple fans, a fan curve shall be provided showing the performance of the entire bank of fans at design conditions. In addition, a fan curve shall be provided showing the performance of each individual fan in the bank of fans at design conditions. Finally, a fan curve shall be provide showing the performance of the bank of fans when one fan is down. The percent redundancy of the bank of fans with one fan down shall be noted on the fan curve or in the tabulated fan data.
14. A filter schedule must be provided for each air handling unit supplied by the air handling unit manufacturer. Schedule shall detail unit tag, unit size, corresponding filter section location within the AHU, filter arrangement (e.g. angled/flat), filter depth, filter type (e.g. pleated media), MERV rating, and filter quantity and size.
15. A schedule detailing necessary trap height shall be provided for each air handling unit. Schedule shall detail unit tag, unit size, appropriate trap schematic with recommended trap dimensions, and unit supplied base rail height. Contractor shall be responsible for additional trap height required for trapping and insulation beyond the unit supplied base rail height by adequate housekeeping pad.The AHU manufacturer shall provide appropriate sets of submittals as referenced in the General Conditions and shall submit to the Owner electronic copies of the IOM.
16. The AHU manufacturer shall list any exceptions to the specification.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air-handling units to include in emergency, operation, and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Filters: Two <2> set(s) for each air-handling unit.
2. Gaskets: One <1> set(s) for each access door.

1.8 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.

C. ARI Certification: Air-handling units and their components shall be factory tested according to ARI 430, "Central-Station Air-Handling Units," and shall be listed and labeled by ARI.

D. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

E. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

F. Comply with NFPA 70.

G. AMCA Publication 99 – Standards Handbook.

H. AMCA Publication 611 – Certified Ratings Program – Airflow Measurement Performance

I. AMCA Standard 500-D – Laboratory Methods of Testing Dampers for Rating.

J. ANSI/ABMA Standard 9 - Load Ratings and Fatigue Life for Ball Bearings.

K. ANSI/AMCA Standard 204 – Balance Quality and Vibration Levels for Fans.

L. ANSI/AHRI Standard 410 - Forced Circulation Air-Cooling and Air-Heating Coils.

M. ANSI/AHRI Standard 430 - Central Station Air Handling Units.

N. ANSI/UL 900 – Standard for Safety Air Filter Units.

O. AHRI Standard 260 – Sound rating of Ducted Air Moving and Conditioning Equipment.

P. ASHRAE Standard 84 - Method of Testing Air-to-Air Heat Exchangers.

Q. ASHRAE Standard 111 – Measurement, Testing, Adjusting, and Balancing of Building HVAC Systems.

R. ASTM B117 - Standard Practice for Operation Salt Spray Apparatus.

S. ASTM E477 – Standard Test Method for Measure Acoustical and Airflow Performance of Duct Liner Materials and Prefabricated Silencers.

T. NFPA 70 – National Electrical Code®.

U. NFPA 90A – Standard for the Installation of Air Conditioning and Ventilation Systems.

V. UL 1995 – Standard for Safety Heating and Cooling Equipment

W. Air Coils: Certify capacities, pressure drops and selection procedures in accordance with current AHRI Standard 410.

X. Air handling units with fan sections utilizing single fans shall be rated and certified in accordance with AHRI Standard 430.

Y. Air handling units with fan sections utilizing multiple fans shall be rated in accordance with AHRI Standard 430 for airflow, static pressure, and fan speed performance.

Z. Airflow monitoring station: Certify airflow measurement station performance in accordance with AMCA 611.

AA. ISO 9001 Certification.

1.9 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

B. Coordinate sizes and locations of structural-steel support members, if any, with actual equipment provided.

1.10 REGULATORY REQUIREMENTS

A. Agency Listings/Certification

B. Unit shall be manufactured to conform to UL 1995 and shall be listed by UL. Units shall be provided with listing agency label affixed to the unit. In the event the unit is not UL approved, the contractor shall, at his/her expense, provide for a field inspection by a UL representative to verify conformance. If necessary, contractor shall perform modifications to the unit to comply with UL as directed by the representative, at no additional expense to the owner.

C. Certify air handling units in accordance with AHRI Standard 430. Units shall be provided with certification label affixed to the unit. If air handling units are not certified in accordance with AHRI Standard 430, contractor shall be responsible for expenses associated with testing of units after installation to verify performance of fan(s). Any costs incurred to adjust fans to meet scheduled capacities shall be the sole responsibility of the contractor.

D. Certify air handling coils in accordance with AHRI Standard 410. Units shall be provided with certification label affixed to the unit. If air handling coils are not certified in accordance with AHRI Standard 410, contractor shall be responsible for expenses associated with testing of coils after installation to verify performance of coil(s). Any costs incurred to adjust coils to meet scheduled capacities shall be the sole responsibility of the contractor.

E. Certify airflow monitoring stations are tested for differential pressure in accordance with AMCA 611 in an AMCA registered laboratory and comply with the requirements of the AMCA Certified Ratings Program. Airflow monitoring station shall be licensed to bear the AMCA Seal.

1.11 DELIVERY, STORAGE, AND HANDLING

A. Comply with manufacturer's installation instructions for rigging, unloading, and transporting units.

NOTE: Units shall be set in the fan rooms prior to enclosure of the rooms as there may be insufficient external openings large enough to accommodate each entire unit.

B. Units shall have tags and airflow arrows on each section to indicate location and orientation in direction of airflow. Shipping splits shall be clearly defined on submittal drawings. Cost associated with non-conformance to shop drawings shall be the responsibility of the manufacturer. Each section shall have lifting lugs for field rigging and final placement of AHU sections. Indoor AHUs less than 100 inches wide shall allow for forklift transport for maneuverability on jobsite.

C. Deliver units to jobsite with fan motor(s), sheave(s), and belt(s) completely assembled and mounted in units.

D. Indoor air handling units shall be shipped in a clear shrink-wrap or stretch-wrap to protect unit from in-transit rain and debris per ASHRAE 62.1 recommendations.

E. Installing contractor shall be responsible for storing AHU in a clean, dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.

1.12 START-UP AND OPERATING REQUIREMENTS

A. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters in place, bearings lubricated (if applicable), condensate properly trapped, piping connections verified and leak-tested, belts aligned and tensioned, all shipping braces removed, bearing set screws torqued, and fan has been test run under observation.

1.13 WARRANTY

A. AHU manufacturer shall provide, at no additional cost, a standard parts warranty that covers a period of one year from unit start-up or 18 months from shipment, whichever occurs first. This warrants that all products are free from defects in material and workmanship and shall meet the capacities and ratings set forth in the equipment manufacturer's catalog and bulletins.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Trane Company.

2.2 GENERAL

A. Unit layout and configuration shall be as defined in project plans and schedule.

B. Modular Multizone Indoor Central Station Variable-Air-Volume Air-Handling Units.

C. Air-Handling Units shall include the following sections:

1. Air mixing section
2. Filter section with MERV 8 filters
3. Indirect Evaporative Cooling Heat Exchanger Section
4. Exhaust-Relief/Vaporizer fan section
5. Access section
6. Direct Evaporative Cooling Section with Full By-Pass Section
7. Access section
8. Preheat Hot water Coil
9. Access section
10. D/X Evaporator Coil:
11. Access section
12. Fan section (2x1 FAN array)
13. Access section
14. Final Filter section with MERV 13 filters
15. Discharge Plenum

2.3 UNIT CASINGS

A. General Fabrication Requirements for Casings:

1. Forming: Form walls, roofs, and floors with at least two breaks at each joint.
2. Casing Joints: Sheet metal screws or pop rivets.
3. Sealing: Seal all joints with water-resistant sealant.

B. Factory Finish: Galvanized-Steel Casings: Immediately after cleaning and pretreating, apply manufacturer's standard two-coat, baked-on enamel finish, consisting of prime coat and thermosetting topcoat.

1. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
2. Indoor air handling unit casing finish to meet ASTM B117 250-hour salt-spray test.
3. Air leakage shall be determined at 1.00 times maximum casing static pressure up to 8 inches w.g. Specified air leakage shall be accomplished without the use of caulk. Total estimated air leakage shall be reported for each unit in CFM, as a percentage of supply air, and as an ASHRAE 111 Leakage Class.

C. Casing Insulation and Adhesive:

1. Materials: ASTM C 1071, Type II.
2. Floor panels shall be double-wall construction and designed to support a 300-lb load during maintenance activities and shall deflect no more than 0.0042” per inch of panel span.
3. Unit casing panels shall be 2” double-wall construction, with solid galvanized exterior and solid galvanized interior, to facilitate cleaning of unit interior.
4. Location and Application: Encased between outside and inside casing.
5. Locations and Applications:

    a. Section: Doors

b. Access Section: Doors.
c. Damper Section: Doors.
d. Filter Section: Doors large enough to allow periodic removal and installation of filters.
e. Mixing Section: Doors.

6. Service Light: LED 100-W vaporproof fixture with switched junction box located outside adjacent to door.

a. Locations: Fan sections, mixing section, filter section, and access sections.

D. Condensate Drain Pans:

1. Fabricated with two percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends).

a. Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.1.
b. Depth: A minimum of 2 inches deep.

2. Integral part of floor plating.
3. Double-wall, galvanized-steel sheet with space between walls filled with foam insulation and moisture-tight seal.
4. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.

a. Minimum Connection Size: NPS 2

5. Material: Stainless Steel.
6. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.

E. Air-Handling-Unit Mounting Frame: Formed galvanized-steel channel or structural channel supports, designed for low deflection, welded with integral lifting lugs.

2.4 FAN, DRIVE, AND MOTOR SECTION

A. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.

1. Shafts: Designed for continuous operation at maximum-rated fan speed and motor horsepower, and with field-adjustable alignment.

a. Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating of lubricating oil.
b. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

B. Fan sections shall have a minimum of one access door located on the drive side of the unit to allow inspection and maintenance of the fan, motor, and drive components. Construct door(s) per Section 2.04.

C. Provide fans of airfoil type and class as specified on the schedule. Fan shafts shall be solid steel, coated with a rust-inhibiting coating, and properly designed so that fan shaft does not pass through first critical speed as unit comes up to rated RPM. All fans shall be statically and dynamically tested by the manufacturer for vibration and alignment as an assembly at the operating RPM to meet design specifications. Fans controlled by variable frequency drives shall be statically and dynamically tested for vibration and alignment at speeds between 25% and 100% of design RPM. If fans are not factory-tested for vibration and alignment, the contractor shall be responsible for cost and labor associated with field balancing and certified vibration performance. Fan wheels shall be keyed to fan shafts to prevent slipping.

D. Belt-driven fans shall be provided with grease lubricated, self-aligning, anti-friction bearings selected for L-50 200,000-hour average life per ANSI/AFBMA Standard 9. Lubrication lines for both bearings shall be extended to the drive side of the AHU and rigidly attached to support bracket with zerk fittings. Lubrication lines shall be a clear, high-pressure, polymer to aid in visual inspection. If extended lubrication lines are not provided, manufacturer shall provide permanently lubricated bearing with engineering calculations for proof of bearing life.

E. All fans, including direct-drive plenum fans, shall be mounted on spring isolation bases. Internally-mounted motor shall be on the same isolation base. Fan and motor shall be internally isolated with 2-inch spring isolators. A flexible connection (e.g. canvas duct) shall be installed between fan and unit casing to ensure complete isolation. Flexible connection shall comply with NFPA 90A and UL 181 requirements.

F. Fan sections containing multiple fans shall be provided as indicated on the schedule and drawings. Each fan shall operate in parallel to each other fan in the array. The fans shall be SWSI plenum type with high efficient AF blades. Fans shall be direct-driven. Fan wheels shall be aluminum. The Hp characteristic of the fans shall be non-overloading.

G. Fan sections containing multiple fans shall be controlled using a common control signal, such as the duct static control signal, to modulate the fan speed.

H. Fan airflow measurement systems shall be provided as indicated on the schedule and drawings to measure fan airflow directly or to measure differential pressure that can be used to calculate airflow. The accuracy of the devices shall be no worse than +5 percent when operating within stable fan operating conditions. Devices shall not affect the submitted fan performance and acoustical levels. Devices that obstruct the fan inlet or outlet shall not be acceptable. Devices shall be connected to transducers with a 2-10 VDC output. Signal shall be proportional to air velocity.

I. Motor: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 23 0513 "Common Motor Requirements for HVAC Equipment."

1. NEMA Premium (TM) efficient motors as defined in NEMA MG 1.
2. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

3. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
4. Mount unit-mounted disconnect switches on exterior of unit.
5. Motors shall meet or exceed all NEMA Standards Publication MG 1 – 2006 requirements and comply with NEMA Premium efficiency levels when applicable. Motors shall comply with applicable requirements of NEC and shall be UL Listed.
6. Fan Motors shall be heavy duty, NEMA Premium efficient ODP, operable at 460 volt/60 Hz/3 phase, exceeding the EPAct efficiency requirements.
7. Belt-driven fan sections with single fans shall use 4-pole (1800 rpm) motors, NEMA Design B, with Class B insulation to operate continuously at 104°F (40°C) ambient without tripping of overloads.
8. Direct-driven fan sections shall use 4-pole (1800 rpm), NEMA Design B, with Class B insulation to operate continuously at 104°F (40°C) ambient without tripping of overloads.
9. Motors shall have a +/- 10 percent voltage utilization range to protect against voltage variation.

J. Variable Frequency Controllers:

1. VFDs shall be field installed. Refer to the drawings and specification section 23 0550 for additional VFD requirements.

2.5 INDIRECT/DIRECT EVAPORATIVE COOLING MODULE WITH ENERGY RECOVERY

A. System description: Provide Indoor Multi-zone VAV Air-Handling unit with factory installed indirect evaporative cooling module with energy recovery. The Stage II indirect/direct evaporative cooling section is designed to sensibly and adiabatically cool ventilation air without the use of refrigerants. It consists of a stainless steel housing and sump, an extended surface cross flow plate exchanger, vaporization fan(s), direct drive TEAO or TEFC motor(s), and direct evaporative media. The Stage II comes with the sump pump and all distribution piping, spray nozzles, bleed valve and balancing valve, and all necessary fittings.

B. Evaporative Cooling Section Sump

The evaporative cooling section sump is fabricated from 16 gauge Type 304 stainless steel. The joints are heli-arc continuously welded to insure full moisture integrity; the sump is factory leak tested and silicone caulked at time of assembly.

C. Indirect Evaporative Cooler

The indirect evaporative cooling section is designed to sensibly cool ventilation supply air without increasing the moisture content. It consists of 18 gauge 304 stainless steel housing, cross flow polymer plate heat exchanger, and exhaust air fan.

D. Heat Exchanger Core

The indirect evaporative dry plate heat exchanger is constructed of non-corrosive polymeric materials. Exchanger plate spacing is controlled by air turbulence spines and is designed to enhance heat transfer and efficiency. Primary and secondary airflow are separated by polymeric adhesives and rubber seals, primary airflow is horizontal and exhaust airflow is vertical in a cross-flow pattern. Air pressure drop shall not exceed 0.5” w.c. at

rated CFM on both the supply and vaporization air streams. The exchanger is constructed in accordance with UL900, UL746C and UL94 standards and tested to meet ATSM 84 Class 1 flame spread rating and smoke development. A triple break mist eliminator is provided to prevent mist carryover from the exchanger. Plates can be acid washed to remove solids, and can be removed from the casing and replaced if damaged or extremely fouled. Indirect exchanger has a limited 10 year factory warranty against material defects and workmanship.

E. Exhaust Fan

The exhaust fan(s) is designed to minimize energy usage and to maximize efficiency. Totally enclosed fan cooled ball bearing motor is selected for belt drive and includes marine shaft coating for corrosion protection. Fan is a forward curve centrifugal type Class K with heavy duty bearings and powder coated fan assembly for corrosion protection. Fan is provided with motor starters and branch circuit protection.

F. Direct Evaporative Section

The direct evaporative section is designed to adiabatically cool, the supply air. The media is housed is a 304 stainless steel casing with removable top section for removal and servicing. A water distribution pad is placed on top of the media for even water distribution. The media is 12" deep high efficient cellulose impregnated with anti-rot solvents and rigidifying saturates and setting agents. Media contains 123 square feet of evaporative surface per cubic foot with a dry weight of 2.4 pounds per cubic foot. Maximum face velocity without water carry-over is 700 FPM.

G. Water Distribution

The re-circulation pumps for the indirect and direct sections are high volume constructed of stainless steel, 1/3 HP, 115/1/60 volt, mounted in the sump. The pump is rated for continuous duty and shall have with thermal overload protection. Piping system has unions for complete disassembly and is constructed of Copper pipe with adjustable balancing and bleed valves. Distribution piping has large 3.8" orifice, cross impingement non corrosive, non clogging nozzles designed to provide a overlap spray pattern to prevent dry spots on the exchanger surface. Unit provided with a Roberts heavy duty brass fill valve with air gap and float with ½ make up water connection, 2" drain connection and 2" overflow connection.

H. Include following Options

1. MERV 8 filters in stainless steel holding racks and hinged side access door.
2. Ruskin CD60 low leakage airfoil dampers with jackshaft and direct coupled actuators.
3. Ruskin AMS050 airflow monitor system to monitor the outside air intake, complete with actuator and transducer.
4. Discharge plenum constructed of 18 gauge galvanized steel double wall insulated panels mounted in an aluminum frame, painted on the interior and exterior, Full height access door hinged with door handles, door is double wall insulated and provides access for removal of the direct evaporative media and header.
5. Control panel for re-circulation pumps only with single power connection, control transformer, fuses and relay all wired to a numbered terminal strip. Panel shall be ETL labeled.

2.6 COIL SECTION

A. General Requirements for Coil Section:

1. Comply with ARI 410.
2. Fabricate coil section to allow removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).
3. Coils shall not act as structural component of unit.
4. See equipment schedule for performance data

B. Coils section side panel shall be removable to allow for removal and replacement of coils without impacting the structural integrity of the unit.

C. Install coils such that headers and return bends are enclosed by unit casing to ensure that if condensate forms on the header or return bends, it is captured by the drain pan under the coil.

D. Coils shall be manufactured with plate fins to minimize water carryover and maximize airside thermal efficiency. Fin tube holes shall have drawn and belled collars to maintain consistent fin spacing to ensure performance and air pressure drop across the coil as scheduled. Tubes shall be mechanically expanded and bonded to fin collars for maximum thermal conductivity. Use of soldering or tinning during the fin-to-tube bonding process is not acceptable due to the inherent thermal stress and possible loss of bonding at that joint.

E. Construct coil casings of galvanized steel. End supports and tube sheets shall have belled tube holes to minimize wear of the tube wall during thermal expansion and contraction of the tube.

F. All coils shall be completely cleaned prior to installation into the air handling unit. Complete fin bundle shall be degreased and cleaned to remove any lubricants used in the manufacturing of the fins, or dirt that may have accumulated, in order to minimize the chance for water carryover.

G. When two or more cooling coils are stacked in the unit, an intermediate drain pan shall be installed between each coil. The intermediate drain pan shall be designed being of sufficient size to collect all condensation produced from the coil and sloped to promote positive drainage to eliminate stagnant water conditions. The intermediate drain pan shall be constructed of the same material as the primary drain pan.

H. The intermediate drain pan shall begin at the leading face of the water-producing device and be of sufficient length extending downstream to prevent condensate from passing through the air stream of the lower coil.

I. Intermediate drain pan shall include downspouts to direct condensate to the primary drain pan. The intermediate drain pan outlet shall be located at the lowest point of the pan and shall be sufficient diameter to preclude drain pan overflow under any normally expected operating condition.

J. Direct Expansion Evaporator Coils.

1. Provide heavy duty aluminum fins mechanically bonded to copper tubes. Evaporator coil shall be inter- circuited to maintain active coil face area at part load conditions. Coil shall also utilize internally enhanced tubing for maximum efficiency.
2. Provide a thermostatic expansion valve (TXV) for each refrigerant circuit. Factory pressure and leak test coil at 300 psi.
3. Provide pitched stainless steel drain pan to assure positive drainage of condensate from the unit casing.

K. Hydronic Coils

1. Supply and return header connections shall be clearly labeled on unit exterior such that direction of coil water-flow is counter to direction of unit air-flow.
2. Coils shall be proof-tested to 300 psig and leak-tested to 200 psig air pressure under water.
3. Headers shall be constructed of round copper pipe or cast iron.
4. Tubes shall be 1/2 inch O.D., minimum tube thickness of 0.016 inch thick copper. Fins shall be aluminum.

2.7 AIR FILTRATION

A. General Requirements for Air Filtration Section:

1. Comply with NFPA 90A.
2. Provide minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
3. Provide filter holding frames arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side (access side)

B. Provide factory-fabricated filter section of the same construction and finish as unit casings. Filter section shall have side access filter guides and access door(s) extending the full height of the casing to facilitate filter removal. Construct doors in accordance with Section 2.04. Provide fixed filter blockoffs as required to prevent air bypass around filters. Blockoffs shall not need to be removed during filter replacement. Filters to be of size and quantity required to maximize filter face area for each air handling unit.

C. Extended-Surface, Disposable Panel Filters:

1. Factory-fabricated, dry, extended-surface type.
2. Thickness: 2 inches
3. Arrestance (ASHRAE 52.1): 90
4. MERV (ASHRAE 52.2): 8 Pre-Filters and MERV 13 Final filters.
5. Media: Pleated media filters made with 100% synthetic fibers that are continuously laminated to a supported steel-wire grid with water repellent adhesive shall be provided. Filters shall be capable of operating up to 625 fpm face velocity without loss of filter efficiency and holding capacity.
6. Mounting Frames: Welded, galvanized steel, with gaskets and fasteners, suitable for bolting together into built-up filter banks.

D. Filter Gage:

1. 3-1/2-inch diameter, diaphragm-actuated dial in metal case.
2. Vent valves.
3. Black figures on white background.
4. Front recalibration adjustment.
5. 2 percent of full-scale accuracy.
6. Range: 0- to 3.0-inch wg.
7. Accessories: Static-pressure tips with integral compression fittings, 1/4-inch aluminum tubing, and 2- or 3-way vent valves.

2.8 DAMPERS

A. Damper Operators: Comply with requirements in Section 23 0900 "Instrumentation and Control for HVAC."

B. All dampers shall be internally mounted. Dampers shall be premium ultra low leak and located as indicated on the schedule and plans. Blade arrangement (parallel or opposed) shall be provided as indicated on the schedule and drawings. Dampers shall be Ruskin CD60 double-skin airfoil design or equivalent for minimal air leakage and pressure drop. Leakage rate shall not exceed 4 CFM/square foot at one inch water gauge complying with ASHRAE 90.1 maximum damper leakage and shall be AMCA licensed for Class 1A. All leakage testing and pressure ratings shall be based on AMCA Standard 500-D. Manufacturer shall submit brand and model of damper(s) being furnished, if not Ruskin CD60.

C. Airflow measuring stations shall be provided and located in the outside and/or return air paths as indicated on the schedule and plans to measure airflow. Airflow measuring stations shall be tested per AMCA Standard 611 and licensed to bear the AMCA Ratings Seal for airflow measurement performance. Integral control damper blades shall be provided as galvanized steel and housed in a galvanized steel frame. Leakage rate shall not exceed 4 CFM/square foot at one inch water gauge complying with ASHRAE 90.1 maximum damper leakage.

D. The airflow measurement station shall measure up to 100 percent of the total outside air and/or return air. The airflow measurement station shall be capable of measuring down to 300 fpm. The airflow measuring device shall adjust for temperature variations. Output shall be provided from the station as a 2-10 VDC signal. Signal shall be proportional to air velocity. The accuracy of the measuring station shall be no greater than +/- 5 percent. Airflow measuring stations shall be mounted on the AHU interior.

2.9 OUTDOOR AIR SECTION

A. Provide 100% modulating economizer section fully integrated with unit return and exhaust air dampers.

B. Provide spring-return motor for outside air damper closure during unit shutdown or power interruption.

C. Provide outside air damper with integral airflow measuring station. Ruskin AMS50 or equivalent.

2.10 DISCHARGE PLENUM SECTION

A. Plenums shall be provided as indicated in the schedule and plans to efficiently turn air and provide acoustical attenuation. Discharge plenum opening types and sizes shall be scaled to meet pressure drop requirements scheduled and align with duct takeoffs.

B. Discharge plenum panels shall be 2 inches and include acoustical liner. The unit construction shall be fabricated from stainless steel perforated material to prevent corrosion and designed to completely encapsulate fiberglass insulation. Insulation material must be resistant to fungi in accordance with ASTM C1338.

2.11 AIR HANDLING UNIT CONTROLS

A. The air handling unit controls shall be furnished by the FMS contractor and installed on the job site. The air handling unit manufacturer shall coordinate the FMS contractor on exact controls requirements related unit safeties and equipment stages. All controls shall comply with Specification 23 0900, Facility Management System, Project Control Diagrams, and Sequence of Operations.

B. The FMS contractor shall furnish installation shop drawings to the air handling unit manufacturer outlining all termination locations and point names. All controls shall comply with Specification 23 0900, Facility Management System, Project Control Diagrams, and Sequence of Operations.

C. The air handling unit manufacturer shall coordinate with FMS contractor on the installation of the system. Once the installation is complete, the FMS contractor shall be notified so that FMS contractor can perform factory start-up and testing of the system prior to the units being shipped to the field.

2.12 SOURCE QUALITY CONTROL

A. Fan Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Fans shall bear AMCA-certified sound ratings seal.

B. Fan Performance Rating: Factory test fan performance for airflow, pressure, power, air density, rotation speed, and efficiency. Rate performance according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating."

C. Water Coils: Factory tested to 300 psig according to ARI 410 and ASHRAE 33.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine casing insulation materials and filter media before air-handling unit installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for steam, hydronic, and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Equipment Mounting: Install air-handling units level on concrete bases. Secure units to anchor bolts installed in concrete bases. Comply with requirements for concrete bases specified in Section 03 3000 "Cast-in-Place Concrete."

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
2. Install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.

B. Arrange installation of units to provide access space around air-handling units for service and maintenance.

C. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with new, clean filters.

D. Install filter-gage, static-pressure taps upstream and downstream of filters. Mount filter gages on outside of filter housing or filter plenum in accessible position. Provide filter gages on filter banks, installed with separate static-pressure taps upstream and downstream of filters.

3.3 CONNECTIONS

A. Comply with requirements for piping specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to air-handling unit to allow service and maintenance.

C. Connect piping to air-handling units with flexible connectors.

D. Connect condensate drain pans using NPS 2, ASTM B 88, Type M copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

E. Hot-Water Piping: Comply with applicable requirements in Section 23 2113 "Hydronic Piping." Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.

F. Refrigerant Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Install shutoff valve and union or flange at each supply and return connection.

G. Connect duct to air-handling units with flexible connections. Comply with requirements in Section 23 3300 "Air Duct Accessories."

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:

1. Leak Test: After installation, fill water coils with water, and test coils and connections for leaks.
2. Charge refrigerant coils with refrigerant and test for leaks.
3. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

D. Air-handling unit or components will be considered defective if unit or components do not pass tests and inspections.

E. Prepare test and inspection reports.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

B. After the Mechanical Contractor has provided all water and refrigerant piping connections, ductwork connections, and field control wiring, and Electrical Contractor has provided all the field power wiring, the Mechanical Contractor shall inspect the installation. The Mechanical Contractor and factory-authorized service representative shall then perform startup of the equipment.

1. The Control’s Contractor shall be scheduled to be at the job site at the time of the equipment start up.
2. Perform the following tests and services and submit a report outlining the results:
3. Record date, time, and person(s) performing service.

4. Lubricate all moving parts.
5. Check all motor and starter power lugs and tighten as required.
6. Verify all electrical power connections.
7. Conduct a start up inspection per the AHU manufacturer's recommendations.
8. Record fan motor voltage and amperage readings.
9. Check fan rotation and spin wheel to verify that rotation is free and does not rub or bind.
10. Check fan for excessive vibration.
11. Check V belt drive or coupling for proper alignment.
12. Check V belt drive for proper tension. Tighten the belts in accordance with the AHU manufacturer's directions. Check belt tension during the second and seventh day's operation and re-adjust belts, as may be required, to maintain proper tension as directed by the AHU manufacturer.
13. Remove all foreign loose material in ductwork leading to and from the fan and in the fan itself.
14. Disengage all shipping fasteners on vibration isolation equipment.
15. Check safety guards to insure they are properly secured.
16. Secure all access doors to the fan, the unit and the ductwork.
17. Switch electrical supply "on" and allow fan to reach full speed.
18. Physically check each fan at start up and shut down to insure no abnormal or problem conditions exist.
19. Check entering and leaving air temperatures (dry bulb and wet bulb) and simultaneously record entering and leaving hot water temperatures and flow, refrigerant pressures and temperatures, and outside air temperature.
20. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm
21. Measure and record motor electrical values for voltage and amperage.
22. Manually operate dampers from fully closed to fully open position and record fan performance.

C. Check all control sequences.

3.6 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.

3.7 CLEANING

A. After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems and after completing startup service, clean air-handling units internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-handling units.

END OF SECTION 23 7313

SECTION 26 0500 - COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General Conditions, Supplemental General Conditions, and Division 1 Specification Sections apply to all Sections of Division 26.

B. The requirements listed under General Conditions and Supplementary Conditions and the General Requirements are applicable to this section and all subsequent sections of Division 26 and form a part of the contract.

C. Division 1, Coordination for additional requirements.

D. Division 1, Cutting and Patching, for additional requirements.

E. Division 1, Submittals, for additional requirements.

F. Division 7, Firestopping, for additional requirements.

G. Division 7, Joint Sealants, for additional requirements.

H. Division 9, Painting, for additional requirements.

I. Division 31, Site Work for Trenching, Backfilling and Compaction requirements.

1.2 SUMMARY

A. This Section includes general administrative and procedural requirements of electrical installations. The following administrative and procedural requirements are included in this Section to expand the requirements specified in Division 1:

1. Submittals
2. Coordination Drawings
3. Record Documents
4. Maintenance Manuals
5. Rough-Ins
6. Electrical Installations
7. Cutting and Patching

1.3 ELECTRICAL DIVISION INDEX

Section 26 0500	Common Work Results for Electrical
Section 26 0519	Low-Voltage Electrical Power Conductors and Cables

Section 26 0526	Grounding and Bonding for Electrical Systems
Section 26 0529	Hangers and Supports for Electrical Systems
Section 26 0533	Raceways and Boxes for Electrical Systems
Section 26 0543	Underground Ducts and Raceways for Electrical Systems
Section 26 0544	Sleeves and Sleeve Seals for electrical Raceway and Cabling
Section 26 0550	Installation Coordination
Section 26 0553	Identification for Electrical Systems
Section 26 0572	Overcurrent Protective Device Short–Circuit Study
Section 26 0573	Overcurrent Protective Device Coordination Study
Section 26 0574	Overcurrent Protective Device Arc-Flash Study
Section 26 0800	Electrical Facility Startup/Commissioning
Section 26 0880	Electrical Acceptance Testing
Section 26 0913	Lighting Control Equipment
Section 26 0923	Digital Occupancy & Daylight Management Control System
Section 26 2213	Low-Voltage Distribution Transformers
Section 26 2413	Switchboards
Section 26 2416	Panelboards
Section 26 2726	Wiring Devices
Section 26 2813	Fuses
Section 26 2816	Enclosed Switches and Circuit Breakers
Section 26 2820	Ground Fault Protection
Section 26 3623	Automatic Transfer Switches
Section 26 4112	Lightning Protection for Structures
Section 26 4313	Surge Protection for Low-Voltage Electrical Power Circuits
Section 26 5119	LED Interior Lighting
Section 26 5219	Emergency and Exit Lighting
Section 26 5619	LED Exterior Lighting

1.4 CODES AND PERMITS

A. Perform electrical work in strict accordance with the applicable provisions of the National Electrical Code, Latest Adopted Edition; National Electric Safety Code, Latest Edition; International Building Code, Latest Adopted Edition as interpreted by the State of New Mexico, City of Dulce, and the National Fire Protection Association (NFPA Regulations), current adopted edition. Provide all materials and labor necessary to comply with rules, regulations and ordinances. Where the drawings and/or specifications indicate materials or construction in excess of code requirements, the drawings and/or specifications shall govern. The Contractor shall hold and save the Engineer free and harmless from liability of any nature or kind arising from his failure to comply with codes and ordinances.

B. Secure and pay for all permits necessary for performance of the work. Pay for all utility connections unless otherwise specified herein.

C. The following lists applicable codes and standards that, as a minimum, shall be followed. All of the latest adopted by the State of New Mexico

Applicable county and state electrical codes, laws and ordinances.

National Electrical Manufacturer's Association Standards

National Electrical Code

National Electrical Safety Code

NFPA 72

Underwriters Laboratories, Inc. Standards

American National Standards Institute

American Society for Testing Materials Standards

Standards and requirements of local utility companies

National Fire Protection Association Standards

Institute of Electrical and Electronics Engineers Standards

Insulated Cable Engineers Association

Occupational Safety and Health Act

Uniform Fire Code

Americans with Disabilities Act

Architectural Barriers Act accessibility Guidelines (ADA/ABBAG) 2004ed.

Commercial and Industrial Insulation Standards (MICA)

New Mexico Night Sky Protection Act.

NFPA 5000

1.5 RECORD DRAWINGS

A. Maintain a complete and accurate set of marked up blue-line prints showing information on the installed location and arrangement of all electrical work, and in particular, where changes were made during construction. Use red color to indicate additions or corrections to prints, green color to indicate deletions, and yellow color to indicate items were installed as shown. Keep record drawings accurate and up-to-date throughout the construction period. Record drawings may be reviewed and checked by the Architect and Owner's Representative during the construction and in conjunction with review and approval of monthly pay requests. Include copies of all addenda, RFI's, bulletins, and change orders neatly taped or attached to record drawing set. Transmit drawings to the Architect and Owner’s Representative at the conclusion of the project for delivery to the Owner's Representative.

B. Prepare record documents in accordance with the requirements in Division 1. In addition to the requirements specified in Division 1, indicate installed conditions for:

1. Major raceway systems, size and location, for both exterior and interior; locations of control devices; distribution and branch electrical circuitry; and fuse and circuit breaker size and arrangements.
2. Equipment locations (exposed and concealed), dimensioned from prominent building lines.
3. Approved substitutions, Contract Modifications, and actual equipment and materials installed.

1.6 QUALIFICATIONS

A. All electricians shall be skilled in their respective trade.

1.7 SUBSTITUTIONS

A. Identification of Division 26 equipment, luminaires, and materials listed within this Specification and in the Equipment Schedules on the drawings, which are identified by manufacturer's name, trade name, and/or model numbers are generally not meant to give preference to any manufacturer, but are provided to establish the design requirements and standards.

B. Equipment submitted for substitution must fit the space conditions leaving adequate room for maintenance around all equipment. A minimum of 36 inches, or more if required by Code, must be maintained clear in front of all electrical panels, starters, gutters, or other electrical apparatus. Submit drawings showing the layout, size and exact method of interconnection of conduit, wiring and controls, which shall conform to the manufacturer's recommendations and these specifications. The scale of these drawings shall be scale of Contract Drawings. The Contractor shall bear the excess costs, by any and all crafts, of fitting the equipment into the space and the system designated. Where additional labor or material is required to permit equipment submitted for substitution to function in an approved manner, this shall be furnished and installed by the Contractor without additional cost to the Owner.

C. Equipment submitted for substitution shall be approved in writing by the Owner or his representative and shall be accompanied by the following:

1. A sample of each item submitted for substitution shall accompany the submittal.
2. Provide a unit price quotation with each item intended for substitution. Include a unit price for the specified item and a unit price for the intended substitute item. Provide a total (per item) of the differential payback to the Owner should the intended substitute item be approved as equivalent to that which is specified.
3. Reimburse the Owner for the Architect/Engineer's additional services required to review and process substitutions.

1.8 PRIOR APPROVAL

The Engineer will not review submittals for electrical equipment prior to bid ("Prior Approvals"). Refer to specification sections and drawings for requirements and approved vendors. All Electrical equipment listed in any section of these specifications has prior approved and acceptable for use or bid.

1.9 HAZARDOUS CONDITIONS

A. Protruding metal (bolts, steel angles, etc.) potentially hazardous to maintenance and operation personnel, shall be cut back and/or protected to reduce the risk of injury.

1.10 DEFINITIONS

A. Definitions of terms will be found in the National Electrical Code.

B. Whenever a term is used in this Specification which is defined in the Code, the definition given will govern its meaning in this Specification.

C. Whenever a technical term is used which does not appear in the Code, the definition to govern its meaning in these Specifications will be found in the Standard Dictionary of Electrical and Electronic Terms, published by the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, Piscataway, New Jersey 08855-1331.

D. "Provide" means furnish, install, connect and test unless otherwise noted.

1.11 SUBMITTALS

A. The Contractor shall submit submittal brochures of equipment, luminaires and materials to be furnished under Division 26. The submittal will be clearly identified with the model number and parts that make up the specified product.

B. Unauthorized Substitutions: If substitute materials, equipment or systems are installed without prior review or are installed in a manner which is not in conformance with the requirement of this Specification and for which the Contractor has not received a written review, removal of the unauthorized materials and installation of those indicated or specified shall be provided at no change in contract amount.

C. Install equipment in accordance with the manufacturer's recommendations. Provide accessories and components for optimum operation as recommended by the manufacturer.

D. Shop Drawings: Unless the following information is included, shop drawings will be returned unchecked:

1. Cover sheet for each submittal, listing equipment, products, and materials, and referencing data and sections in Specifications and drawings. Clearly reference project name and provide space for a review stamp.
2. Cover sheet shall clearly identify deviations from specifications, and justification.
3. Include all related equipment in a single submittal to allow complete review. Similar equipment may be submitted under a common cover sheet.
4. Size, dimensions, diagrams of electrical systems, and weight of equipment.
5. Equipment performance under specified conditions, not a copy of scheduled data on drawings.
6. Indicate actual equipment proposed, where data sheets indicate more than one (1) device or equipment.

E. Use of substitutions reviewed and checked by the Engineer does not relieve the Contractor from compliance with the Contract Documents. Contractor shall bear all extra expense resulting from the use of any substitutions where substitutions affect adjoining or related work required in this Division

or other Divisions of this Specification.

F. If Contractor substitutes equipment for that drawn to scale on the drawings, he shall prepare a 1/4" = 1'-0" installation drawing for each equipment room where a substitution is made, using dimensions of substituted equipment, and including piping, and electrical equipment requirements, to verify that equipment will fit space with adequate clearances for maintenance. This 1/4" = 1'-0" fabrication drawing shall be submitted, for review by the Architect, Engineer, and Owner's Representative, with the shop drawing submittals of the substituted. Failure to comply with this requirement will result in the shop drawings being returned unchecked.

G. Submittals and one (1) resubmittal will be reviewed by the Architect/Engineer. If the Contractor fails to provide the required data with his second submittal, he will be charged for the third and subsequent reviews.

H. The Contractor shall submit amount of copies and type, electronic or hard copies, of submittal brochures for review per Division 1 requirements. Brochures shall be submitted within thirty (30) days after contract award. Copies of all submittals will be retained by the Architect, Engineer, and Owner's Representative. Additional copies of submittals, if required by the Contractor, shall be reproduced by the Contractor from the reviewed and marked sets returned to the Contractor.

I. Refer to specification Section 01 8113 Part 1.5 for LEED product submittal requirements.

1.12 MAINTENANCE MANUALS

A. Prepare maintenance manuals in accordance with Division 1. In addition to the requirements specified in Division 1, include the following information for equipment items:

1. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.
2. Manufacturer’s printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.
3. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
4. Servicing instructions and lubrication charts and schedules.
5. Provide manual on all equipment requiring submittal review and the following systems and equipment as a minimum:

    a. Switchboards
    b. Panelboards
    c. Transformers
    d. Luminaires
    e. Lighting Control Devices
    f. Fire Alarm
    g. Lightning Protection
    h. TVSS Equipment
    i. Metering Equipment

1.13 COORDINATION DRAWINGS

A. Prepare coordination drawings in accordance with Division 1, to a scale of 1/4" = 1'-0" or larger; detailing major elements, components, and systems of electrical equipment and materials in relationship with other systems, installations, and building components. Indicate locations where space is limited for installation and access and where sequencing and coordination of installations are of importance to the efficient flow of the Work, including (but not necessarily limited to) the following:

1. Indicate the proposed locations of major raceway systems, equipment, and materials. Include the following:

    a. Clearances for servicing equipment, including space for equipment disassembly required for periodic maintenance.
    b. Exterior wall and foundation penetrations.
    c. Fire-rated wall and floor penetrations.
    d. Equipment connections and support details.
    e. Sizes and location of required concrete pads and bases.

2. Indicate scheduling, sequencing, movement, and positioning of large equipment into the building during construction.
3. Prepare floor plans, elevations, and details to indicate penetrations in floors, walls, and ceilings and their relationship to other penetrations and installations.
4. Prepare reflected ceiling plans to coordinate and integrate installations, air outlets and inlets, luminaires, communications systems components, sprinklers, and other ceiling-mounted devices.

1.14 USE OF CADD FILES

A. Under certain conditions, the Contractor will be permitted the use of the Engineer's REVIT model/files for documentation of as-builts, submittals, or coordination drawings.

B. The Engineer shall be compensated for the time required to format the REVIT model/files for delivery to the Contractor. Such work may include removal of title blocks, professional seals, calculations, proprietary information, etc.

C. The Contractor shall complete the enclosed License, Indemnity and Warranty Agreement, complete with contractor's name, address, and Contractor's Representative signature prior to request for REVIT model/file usage.

1.15 DRAWINGS AND SPECIFICATIONS

A. Electrical drawings are diagrammatic, but shall be followed as closely as actual construction and work of the other sections shall permit. Size and location of equipment is drawn to scale wherever possible. Do not scale from electrical drawings.

B. Drawings and specifications are for the assistance and guidance of the Contractor. Exact locations, distances, and levels will be governed by the building. The Contractor shall make use of data in all the Contract Documents to verify information at the building site.

C. In any case where there appears to be a conflict between that which is shown on the electrical drawings, and that shown in any other part of the Contract Documents, the Contractor shall notify and secure directions from the Architect.

D. Drawings and specifications are intended to complement each other. Where a conflict exists between the requirements of the drawings and/or the specifications, request clarification. Do not proceed with work without direction.

E. The Architect shall interpret the drawings and the specifications. The Architect's interpretation as to the true intent and meaning thereof and the quality, quantity, and sufficiency of the materials and workmanship furnished there under shall be accepted as final and conclusive.

F. In the case of conflicts not clarified prior to the bidding deadline, use the most costly alternative (better quality, greater quantity, and larger size in meeting design intent and code requirements) in preparing the bid. A clarification will be issued to the successful bidder as soon as feasible after the award and, if appropriate, a deductive change order will be issued.

G. Where items are specified in the singular, this division shall provide the quantity as shown on drawings plus any spares or extras indicated on the drawings or in the specifications.

H. Investigate structural and finish conditions and arrange work accordingly. Provide all fittings, equipment, and accessories required for actual conditions.

1.16 SIMILAR MATERIALS

A. All items of a similar type shall be products of the same manufacturer.

B. Contractor shall coordinate among suppliers of various equipment to assure that similar equipment type is product of the same manufacturer.

C. Examples of similar equipment types include but are not limited to:

1. Power Circuit Breakers
2. Enclosed Case Circuit Breakers
3. TVSS
4. Motor Starters
5. Transformers
6. Panelboards
7. Disconnects
8. Fuses
9. Transfer Switch

1.17 DELIVERY, STORAGE AND HANDLING

A. Deliver products to the project properly identified with names, model numbers, types, grades, compliance labels, and other information needed for identification.

1.18 GUARANTEE-WARRANTY

A. See Division 1 for warranties.

B. The following guarantee is a part of the specifications and shall be binding on the Contractor:

> "The Contractor guarantees that this installation is free from ALL defects. He agrees to replace or repair any part of the installation which may fail within a period of one (1) year after date established below, provided that such failure is due to defects in the materials or workmanship or to failure to follow the specifications and drawings. Warranty of the Contractor-furnished equipment or systems shall begin on the date the system or equipment is placed in operation for beneficial use of the Owner or occupancy by the Owner, whichever occurs first; such date to be determined in writing by means of issuing a 'Certificate of Substantial Completion', AIA Form G704."

C. The extent of guarantees or warranties by Equipment and/or Materials Manufacturers shall not diminish the requirements of the Contractor's guarantee-warranty to the Owner.

D. All items of electrical equipment furnished and installed under Division 26 shall be provided with a full one (1) year parts and labor warranty.

PART 2 - PRODUCTS

2.1 QUALITY OF MATERIALS

A. All equipment and materials shall be new, and shall be the standard product of manufacturers regularly engaged in the production of electrical equipment, and shall be the manufacturer's latest design. Specific equipment, shown in schedules on drawings and specified herein, is to set forth a standard of quality and operation.

B. Hazardous or Environmentally Damaging Materials: Products shall not contain asbestos, mercury, PCBs, or other materials harmful to people or the environment.

2.2 ALTITUDE RATINGS

A. Unless otherwise noted, all specified equipment capacities are for an altitude of this project site in feet above sea level and adjustments to manufacturer's ratings must be made accordingly. Contractor

to verify elevation prior to ordering of any electrical equipment.

2.3 LEED

A. Provide submittals as required by Section 01 8113 Supplemental Table(s):
   1. Submittal Requirements for LEED v4 Materials and Resources Credits.
   2. Submittal Requirements for LEED v4 Environmental Quality Credits.

B. Low Emitting Materials
   1. All adhesives, sealants, paints, and coatings applied onsite to a location inside the building weatherproofing system must comply with the low-emitting requirements listed in Section 01352 LEED Requirements. Provide VOC information required on the LEED Submittal Cover Sheet included at the end of this section.

2.4 EQUIPMENT REQUIREMENTS

A. The electrical requirements for equipment specified or indicated on the drawings are based on information available at the time of design. If equipment furnished for installation has electrical requirements other than those indicated on the electrical drawings, make all adjustments to wire and conduit size, controls, over current protection and installation as required to accommodate the equipment supplied. Delineate all adjustments to the drawings reflecting the electrical system in a submittal to the Contract Administrator immediately upon knowledge of the required adjustment.

B. Approved Equipment and Conductors: ALL equipment and conductors shall be listed and labeled by a nationally recognized testing laboratory (NRTL). The NRTL shall be listed by the federal occupational safety and health administration. Conformance with the State of New Mexico Electrical Code article 110.2 is required for ALL equipment and conductors.

PART 3 - EXECUTION

3.1 COOPERATION WITH OTHER TRADES

A. Coordinate all work so that the construction operations can proceed without harm to the Owner from interference, delay, or absence of coordination. The Contractor shall be responsible for the size and accuracy of all openings. All coordination between trades will occur prior to commencement of any work.

3.2 DRAWINGS

A. The electrical drawings show the general arrangement of all lighting, power, special systems, equipment, etc., and shall be followed as closely as actual building construction and work of other trades will permit. Whenever discrepancies occur between plans and specifications, the most stringent shall govern. All Contract Documents shall be considered as part of the work. Coordinate with architectural, mechanical, and structural drawings. Because of the small scale of the electrical drawings, it is not possible to indicate all offsets, fittings and accessories which may be required.

Provide all fittings, boxes, and accessories as may be required to meet actual conditions. Should conditions necessitate a rearrangement of equipment, such departures and the reasons therefore, shall be submitted by the Contractor for review in the form of detailed drawings showing the proposed changes. No changes shall be made without the prior written approval. All changes shall be marked on record drawings.

B. Should any doubt or question arise in respect to the true meaning of the drawings or specifications, the question shall be submitted in writing.

C. Installation of all equipment shall be arranged to provide all clearances required for equipment operation, service, and maintenance, including minimum clearance, as defined by the National Electrical Code (NEC).

D. The Contractor's attention is directed to the unique architectural design features and consideration associated with this facility which will require significantly greater levels of coordination and cooperation for the work furnished and installed under Division 26 with the associated architectural, structural, and mechanical work than is normally necessary for a more typical facility.

E. The installation of all concealed electrical systems shall be carefully arranged to fit within the available space without interference with adjacent structural and mechanical systems.

3.3 ELECTRICAL INSTALLATIONS

A. General: Sequence, coordinate, and integrate the various elements of electrical system, materials, and equipment. Comply with the following requirements:

1. Coordinate electrical systems, equipment, and materials installation with all other building components.
2. Verify all dimensions by field measurements.
3. Arrange for chases, slots, and openings in all other building components during progress of construction, to allow for electrical installations.
4. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components as they are constructed.
5. Sequence, coordinate, and integrate installations of electrical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building.
6. Where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide the maximum clearance possible.
7. Coordinate connection of electrical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.
8. Multi-branch circuits throughout facility to have an individual neutral for each phase for branch circuits.
9. Install systems, materials, and equipment to conform with approved submittal data, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer conflict to the Architect.

10. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components.
11. Install electrical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.
12. Install access panel or doors where units are concealed behind finished surfaces.
    Install systems, materials, and equipment giving right-of-way priority to systems requiring installation at a specified slope.
13. Provide submittals as required by Section 01 8113 Supplemental Table
    a. Submittal Requirements for LEED v4 Environmental Quality Credits.

3.4 FIELD MEASUREMENTS

A. No extra compensation shall be claimed or allowed due to differences between actual dimensions, including dimensions of equipment, fixtures and materials furnished, and those indicated on the drawings. Contractor shall examine adjoining work, and shall report any work which must be corrected. Review of submittal data in accordance with paragraph "Submittals" shall in no manner relieve the Contractor of responsibility for the proper installation of the electrical work within the available space. Installation of equipment and systems within the building space shall be carefully coordinated by the Contractor.

3.5 EQUIPMENT SUPPORT

A. Provide support for equipment to the building structure. Provide all necessary structures, inserts, sleeves, firestops and hanging devices for installation of equipment. Coordinate installation of devices. Verify with the Architect that the devices and supports are adequate as intended and do not overload the building's structural components in any way.

3.6 PAINTING

A. All finish painting of electrical systems and equipment will be under "Painting," unless equipment is hereinafter specified to be painted.

B. All equipment shall be provided with factory applied standard finish, unless otherwise specified.

C. Touch-Up: If the factory finish on any equipment is damaged in shipment or during construction of the building, the equipment shall be refinished to the satisfaction of the Architect and Owner's Representative.

3.7 SEISMIC SUPPORTS

Seismic supports for electrical equipment and systems will meet the requirements for seismic classification of this project.

3.8 PROTECTION OF MATERIALS AND EQUIPMENT

A. The Contractor shall be responsible for the protection of all work, materials and equipment furnished and installed under this section of the specifications, whether incorporated in the building or not.

B. All items of electrical equipment shall be stored in a protected weatherproof enclosure prior to installation within the building, or shall be otherwise protected from the weather in a suitable manner approved by the Architect and Owner's Representative.

C. The Contractor shall provide protection for all work and shall be responsible for all damage done to property, equipment and materials. Storage of materials within the building shall be approved by the Architect and Owner's Representative prior to such storage.

D. Conduit openings shall be closed with caps or plugs, or covered to prevent lodgment of dirt or trash during the course of installation. At the completion of the work, luminaires, equipment and materials shall be cleaned and polished thoroughly and delivered in a condition satisfactory to the Architect.

3.9 EXCAVATION

A. Provide all excavation, trenching and backfilling required.

B. Slope sides of excavations to comply with codes and ordinances. Shore and brace as required for stability of excavation.

3.10 ERECTION OF METAL SUPPORTS AND ANCHORAGE

A. Cut, fit, and place miscellaneous metal fabrications accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

B. Field Welding: Comply with AWS "Structural Welding Code."

3.11 ERECTION OF WOOD SUPPORTS AND ANCHORAGE

A. Cut, fit, and place wood grounds, nailers, blocking, and anchorage accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

B. Select fastener sizes that will not penetrate members where opposite side will be exposed to view or will receive finish materials. Make tight connections between members. Install fasteners without splitting wood members.

C. Attach to substrates as required to support applied loads.

3.12 APPLICATION OF JOINT SEALERS

A. General: Comply with joint sealer manufacturer's printed application instructions applicable to products and applications indicated, except where more stringent requirements apply.

1. Comply with recommendations of ASTM C 962 for use of elastomeric joint sealants.
2. Comply with recommendations of ASTM C 790 for use of acrylic-emulsion joint sealants.

B. Immediately after sealant application and prior to time shinning or curing begins, tool sealants to form smooth, uniform beads; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint. Remove excess sealants from surfaces adjacent to joint. Do not use tooling agents that discolor sealants or adjacent surfaces or are not approved by sealant manufacturer.

C. Firestopping Sealant: Provide sealant, including forming, packing, and other accessory materials, to fill openings around electrical services penetrating floors and walls, to provide fire-stops with fire-resistance ratings indicated for floor or wall assembly in which penetration occurs. Comply with installation requirements established by testing and inspecting agency.

3.13 INSTALLATION OF ACCESS DOORS

A. Set frames accurately in position and securely attached to supports, with face panels plumb and level in relation to adjacent finish surfaces.

B. Adjust hardware and panels after installation for proper operation.

3.14 CUTTING AND PATCHING

A. Perform cutting and patching in accordance with Division 1. In addition to the requirements specified in Division 1, the following requirements apply:

1. Perform cutting, fitting, and patching of electrical equipment and materials required to:

    a. Remove and replace defective Work.
    b. Remove and replace Work not conforming to requirements of the Contract Documents.
    c. Remove samples of installed Work as specified for testing.
    d. Install equipment and materials in existing structures.
    e. Upon written instructions from the Contracting Officer, uncover and restore Work to provide for Contracting Officer observation of concealed Work.

2. Cut, remove, and legally dispose of selected electrical equipment, components, and materials as indicated, including but not limited to removal of electrical items indicated to be removed and items made obsolete by the new Work.
3. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.
4. Provide and maintain temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to adjacent areas.
5. During cutting and patching operations, protect adjacent installations.
6. Patch existing finished surfaces and building components using new materials matching

existing materials and experienced installers.

3.15 MANUFACTURER'S INSTRUCTIONS

A. All equipment shall be installed in strict accordance with recommendations of the manufacturer. If such recommendations conflict with plans and specifications, the Contractor shall submit such conflicts to the Architect who shall make such compromises as he deems necessary and desirable.

3.16 CONCRETE BASES AND HOUSEKEEPING PADS

A. Install concrete bases and housekeeping pads under all freestanding electrical equipment unless otherwise noted.

B. Contractor shall be responsible for the accurate dimensions of all pads and bases and shall furnish and install all anchor bolts, etc. Coordinate weight of concrete bases and housekeeping pads with the structural engineer.

C. All concrete bases and housekeeping pads shall conform to the requirements specified under Division 3, Concrete, portions of these specifications. Pad foundations shall be 4" high minimum, unless otherwise indicated on the drawings. Chamfer edges shall be 1". Faces shall be free of voids and rubbed smooth with Carborundum block after stripping forms. Tops shall be level. Provide dowel rods or other required material in floor for lateral stability and anchorage.

3.17 TESTS

A. All tests shall be conducted in the presence of the designated and authorized Owner's Representative. The Contractor shall notify the Architect one week in advance of all tests. The Contractor shall furnish all necessary equipment, materials, and labor to perform the required tests.

3.18 OPERATION AND MAINTENANCE INSTRUCTIONS

A. The Contractor shall furnish the complete operating and maintenance instructions covering all units of electrical equipment herein specified together with parts lists. Furnish four (4) copies of all the literature; each shall be suitably bound in loose leaf book form.

B. Operating and maintenance manuals as required herein shall be submitted for review not less than two (2) weeks prior to the date scheduled for the Contractor to provide Operating and Maintenance Instructions to the Owner as specified herein.

C. Upon completion of all work and all tests, Contractor shall furnish the necessary skilled labor and helpers for operating the electrical systems and equipment for a period of three (3) days of eight (8) hours each. During this period, the Contractor shall instruct the Owner or his representative in the operations, adjustment and maintenance of all equipment furnished. Contractor shall provide at least two weeks notice in advance of this period, with a written schedule of each training session, the subject of the session, the Contractors' representatives who plan to attend the session, and the time for each session.

D. The Contractor shall video tape the instruction and training sessions using a DVD recorder, and at the completion and acceptance (by Owner and Architect) of the training sessions, the Contractor shall submit (4) copies of the video the recordings.

1. General

    a. Electrical systems training will be conducted in a classroom setting, with field demonstrations as appropriate, using system and component documentation and suitable classroom training aids.
    b. The location of the training shall be determined by the Contracting Officer.
    c. For all systems requiring training, a factory-authorized service representative shall be engaged to train the BIA's maintenance personnel as specified below:

        1) Provide training on starting up and shutting down, operating, troubleshooting, servicing, adjusting, and maintaining equipment and maintenance schedules. A minimum of three hours' training, or as noted below, shall be provided for each system.
        2) Use the approved final version of the operations and maintenance (O&M) manuals as training aids. Training shall not commence until approved O&M manuals are available.
        3) Training shall be scheduled with the owner with at least two weeks' advance notice.

    d. All information provided in the training sessions shall be provided in written format and included in the O&M manuals. The training information shall be separated per subject for inclusion adjacent to the associated drawings, data sheets, etc., in the O&M manual.

2. Switchboards

    a. Provide training as required by owner. Training will be video taped for owners future use.
    b. The training session shall include instruction on the assembly, switches, changing fuses, checking torque on bus and cable connections, programming, viewing meter parameters, and other major components.

3. Transient Voltage Surge Suppressor

    a. The manufacturer's representative shall also provide training on the theory of the transient voltage surge suppressor (TVSS) system.

4. Fire Alarm

    a. Provide a minimum of eight hours' training.

5. Other Systems to Be Included in the Training Sessions

    a. Lighting controls.
    b. Lightning protection.
    c. Other systems requiring maintenance or troubleshooting.

3.19 CERTIFICATIONS

A. Before receiving final payment, certify in writing that all equipment furnished and all work done is in compliance with all applicable codes mentioned in these specifications. Submit certifications and acceptance certificates to the Architect including proof of delivery of O&M manuals, spare parts required, and equipment warranties which shall be bound with O&M manuals.

3.20 INTERRUPTING SERVICES

A. The Contractor shall coordinate the installation of all work in the building and on the project site in order to minimize interference with the operation of existing facilities electrical, telephone, fire alarm/protection, and utility systems during construction. Connections to existing systems requiring the interruption of services to existing on site facilities shall be carefully coordinated with the Owner and associated utility companies' representative to minimize system downtimes. Requests for the interruption of existing services shall be submitted in writing a minimum of two (2) weeks before the scheduled date. Absolutely no interruption of the existing services will be permitted without the written review.

3.21 OPERATION PRIOR TO ACCEPTANCE

A. Operation of equipment and systems installed by the Contractor, for the benefit of the Contractor, except for the purposes of testing and balancing will not be permitted without a written agreement between the Owner, Architect, and the Contractor establishing warranty and other responsibilities.

3.22 SITE VISITS AND OBSERVATION OF CONSTRUCTION

A. The Architect/Engineer will make periodic visits to the project site at various stages of construction in order to observe the progress and quality of various aspects of the Contractor's work, in order to determine in general if such work is proceeding in accordance with the Contract Documents. This observation by the Architect/Engineer however, shall in no way release the Contractor from his complete responsibility to supervise, direct, and control all construction work and activities, nor shall the Architect/Engineer have authority over, or a responsibility to means, methods, techniques, sequences, or procedures of construction provided by the Contractor or for safety precautions and programs, or for failure by the Contractor to comply with all law, regulations, and codes.

END OF SECTION 26 0500

DIVISION 26 SUBSTITUTION REQUEST FORM (SRF)

TO: BRIDGERS & PAXTON CONSULTING ENGINEERS, INC.
PROJECT: _____

We hereby submit for your consideration the following product instead of the specified item for the above project:
Section: _____ Page: _____ Paragraph/Line: _____ Specified Item: _____
Proposed Substitution: _____
Attach complete product description, drawings, photographs, performance and test data, and other information necessary for evaluation. Identify specific Model Numbers, finishes, options, etc.

1. Will changes be required to building design in order to properly install proposed substitutions? YES ☐ NO ☐
   If YES, explain: _____

2. Will the undersigned pay for changes to the building design, including engineering and drawing costs, caused by requested substitutions? YES ☐ NO ☐

3. List differences between proposed substitutions and specified item.

Specified Item	Proposed Substitution

4. Does substitution affect Drawing dimensions? YES ☐ NO ☐

5. What affect does substitution have on other trades? _____

6. Does the manufacturer's warranty for proposed substitution differ from that specified? YES ☐ NO ☐
   If YES, explain: _____

7. Will substitution affect progress schedule? YES ☐ NO ☐
   If YES, explain: _____

8. Will maintenance and service parts be locally available for substitution? YES ☐ NO ☐
   If YES, explain: _____

9. Is substitution identical in appearance and function to specialized product? YES ☐ NO ☐

Submitting Firm: _____ Date: _____
Address: _____
Signature: _____ Telephone: _____

For Engineer's Use Only
Accepted: _____ Not Accepted: _____ Received Too Late: _____
By: _____ Date: _____
Remarks: _____

LICENSE AGREEMENT FOR CADD DATABASE OR BIM MODEL

PROJECT: _____

LICENSE GRANT: Contractor is granted use of the CADD Database or BIM Model (Database/Model) for the indicated project for the specific purpose of preparing submittal documents for this Project. No other use of the Database/Model is granted. Title to the Database/Model is not transferred to the Contractor. The Database/Model may be of value to the Contractor in preparing submittals, but use of the model does not relieve the contractor of the requirement to verify measurements in the field.

COPYING RESTRICTIONS: Contractor may copy the Database/Model in whole or in part, but only for backup and archival purposes or for use by the Contractor's Subcontractors. Contractor agrees to ensure that any entities that receive the Database/Model from Contractor, either in whole or in part, comply with the terms and conditions of this agreement. Contractor shall safeguard the Database/Model from falling into the hands of parties other than Subcontractors with a legitimate need for it.

WARRANTY: Bridgers & Paxton (B&P) offers this Database/Model without warranty and specifically without express or implied warranty of fitness. If Contractor chooses to use the Database/Model, then he does so at his own risk and without any liability or risk to B&P.

INDEMNITY: Contractor shall to the fullest extent permitted by law, defend, indemnify and hold harmless the Owner, Architect, B&P, their employees and agents from all claims, damages, losses, and attorney fees arising out of or resulting from the use of the Database/Model.

ACKNOWLEDGMENT: Contractor acknowledges that (s)he has read this Agreement, understands it, and agrees to be bound by its terms and conditions.

CONTRACTOR'S REPRESENTATIVE

Signature: _____ Company Name: _____

Name: _____ Address 1: _____

Title: _____ Address 2: _____

Date: _____

SECTION 26 0519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes building wires and cables and associated splices, connectors, and terminations for wiring systems rated 600 volts and less.

B. Related Sections: The following Sections contain requirements that relate to this Section:

1. Division 26, Section 26 0529, Hangers and Supports for Electrical Systems for supports and anchors for fastening cable directly to building finishes.
2. Division 26, Section 26 0553, Identification for Electrical Systems for insulation color coding and wire and cable markers.

1.3 INFORMATIONAL SUBMITTALS

A. Field test reports indicating and interpreting test results relative to compliance with performance requirements of testing standard.

1.4 QUALITY ASSURANCE

A. Testing Qualifications: Contractor will follow NETA requirements.

PART 2 - PRODUCTS

2.1 COPPER BUILDING WIRE

A. Description: Flexible, insulated and uninsulated, drawn copper current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Alpha Wire Company.
2. American Bare Conductor.
3. Belden Inc.
4. Cerro Wire LLC.

5. Encore Wire Corporation.
6. General Cable Technologies Corporation.
7. Okonite Company (The).
8. Service Wire Co.
9. Southwire Company.

C. Standards:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
2. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

D. Conductors: Copper, complying with ASTM B 3 for bare annealed copper and with ASTM B 8 and/or ASTM B 496 for stranded conductors.

E. Conductor Insulation:

1. Type NM: Comply with UL 83 and UL 719.
2. Type THHN and Type THWN-2: Comply with UL 83.

F. Shield:

1. Type TC-ER: Cable designed for use with VFCs, with oversized crosslinked polyethylene insulation, spiral-wrapped foil plus 85 percent coverage braided shields and insulated full-size ground wire, and sunlight- and oil-resistant outer PVC jacket.

2.2 CONNECTORS AND SPLICES

A. Description: Factory-fabricated connectors, splices, and lugs of size, ampacity rating, material, type, and class for application and service indicated; listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. 3M Electrical Products.
2. AFC Cable Systems; a part of Atkore International.
3. Gardner Bender.
4. Hubbell Power Systems, Inc.
5. Ideal Industries, Inc.
6. ILSCO.
7. NSi Industries LLC.
8. O-Z/Gedney; a brand of Emerson Industrial Automation.
9. Service Wire Co.
10. TE Connectivity Ltd.

C. Jacketed Cable Connectors: For steel and aluminum jacketed cables, zinc die-cast with set screws, designed to connect conductors specified in this Section.

D. Lugs: One piece, seamless, designed to terminate conductors specified in this Section.

1. Material: Copper.
2. Type: Two hole with standard barrels.
3. Termination: Compression.

E. Wire nuts: Use twist type wire nuts for splicing smaller gauge conductors. Use of WAGO type push connectors is prohibited on any wire splicing.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper; solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Feeders: Copper for feeders smaller than No. 4 AWG; copper. Conductors shall be solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

C. Branch Circuits: Copper. Solid for No. 12 AWG minimum; stranded for No. 10 AWG and larger.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type THHN/THWN-2, single conductors in raceway.

B. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN/THWN-2, single conductors in raceway.

C. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway, Type XHHW-2, single conductors in raceway, Underground feeder cable, Type UF.

D. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single conductors in raceway.

E. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway.

F. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Minimum size conductor to install throughout will be No. 12 AWG.

B. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.

C. Complete raceway installation between conductor and cable termination points according to Section 26 0533 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.

D. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

E. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips that will not damage cables or raceway.

F. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

G. Support cables according to Section 26 0529 "Hangers and Supports for Electrical Systems."

H. Complete cable tray systems installation according to Section 27 0536 "Cable Trays for Electrical Systems" prior to installing conductors and cables.

3.4 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

B. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

C. Wiring at Outlets: Install conductor at each outlet, with at least 12 inches of slack.

3.5 IDENTIFICATION

A. Identify and color-code conductors and cables according to Section 26 0553 "Identification for Electrical Systems."

B. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

3.6 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 26 0544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.7 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Section 07 8400 "FIRESTOPPING."

3.8 FIELD QUALITY CONTROL

A. Perform tests and inspections with the assistance of a factory-authorized service representative.

1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors for compliance with requirements.
2. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors and conductors feeding the following critical equipment and services for compliance with requirements:

    a. Electrical distribution equipment.
    b. Wiring devices
    c. Mechanical and Plumbing equipment
    d. Pool equipment
    e. Kitchen and Concessions Equipment
    f. Bowling Alley Equipment.
    g. Site equipment

3. Perform each of the following visual and electrical tests:

    a. Inspect exposed sections of conductor and cable for physical damage and correct connection according to the single-line diagram.
    b. Test bolted connections for high resistance using one of the following:

        1) A low-resistance ohmmeter.
        2) Calibrated torque wrench.
        3) Thermographic survey.

    c. Inspect compression-applied connectors for correct cable match and indentation.
    d. Inspect for correct identification.
    e. Inspect cable jacket and condition.
    f. Insulation-resistance test on each conductor for ground and adjacent conductors. Apply a potential of 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable for a one-minute duration.
    g. Continuity test on each conductor and cable.
    h. Uniform resistance of parallel conductors.

4. Initial Infrared Scanning: After Substantial Completion, but before Final Acceptance, perform an infrared scan of each splice in conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner. Correct deficiencies determined during the scan.

    a. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

b. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

5. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Substantial Completion.

B. Cables will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports to record the following:

1. Procedures used.
2. Results that comply with requirements.
3. Results that do not comply with requirements, and corrective action taken to achieve compliance with requirements.

END OF SECTION 26 0519

SECTION 26 0526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes grounding and bonding systems and equipment.

B. Section includes grounding and bonding systems and equipment, plus the following special applications:

1. Ground bonding common with lightning protection system.
2. Foundation steel electrodes.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans showing dimensioned locations of grounding features specified in "Field Quality Control" Article, including the following:

1. Test wells.
2. Ground rods.
3. Ground rings.
4. Grounding arrangements and connections for separately derived systems.

B. Qualification Data: For testing agency and testing agency's field supervisor.

C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 01 7800 "CLOSEOUT SUBMITTALS," include the following:

a. Plans showing as-built, dimensioned locations of grounding features specified in "Field Quality Control" Article, including the following:

1) Test wells.
2) Ground rods.
3) Grounding arrangements and connections for separately derived systems.

b. Instructions for periodic testing and inspection of grounding features at test wells, ground rings, grounding connections for separately derived systems, electrical equipment, based on NETA MTS and NFPA 70B.

1) Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.
2) Include recommended testing intervals.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Contractor will follow all NETA requirements.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with UL 467 for grounding and bonding materials and equipment.

2.2 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Burndy; Part of Hubbell Electrical Systems.
2. Dossert; AFL Telecommunications LLC.
3. ERICO International Corporation.
4. Fushi Copperweld Inc.
5. Galvan Industries, Inc.; Electrical Products Division, LLC.
6. Harger Lightning & Grounding.
7. ILSCO.
8. O-Z/Gedney; a brand of Emerson Industrial Automation.
9. Robbins Lightning, Inc.
10. SIEMENS Industry, Inc.; Energy Management Division.

2.3 CONDUCTORS

A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:

1. Solid Conductors: ASTM B 3.
2. Stranded Conductors: ASTM B 8.
3. Tinned Conductors: ASTM B 33.
4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
6. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8inches wide and 1/16 inch thick.
7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

C. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches in cross section, with 9/32-inch holes spaced 1-1/8 inches apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V and shall be Lexan or PVC, impulse tested at 5000 V.

2.4 CONNECTORS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.

B. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

C. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

D. Bus-Bar Connectors: Compression type, copper or copper alloy, with two wire terminals.

E. Beam Clamps: Mechanical type, terminal, ground wire access from four directions, with dual, tin-plated or silicon bronze bolts.

F. Cable-to-Cable Connectors: Compression type, copper or copper alloy.

G. Cable Tray Ground Clamp: Mechanical type, zinc-plated malleable iron.

H. Conduit Hubs: Mechanical type, terminal with threaded hub.

I. Ground Rod Clamps: Mechanical type, copper or copper alloy, terminal with hex head bolt.

J. Ground Rod Clamps: Mechanical type, copper or copper alloy, terminal with hex head bolt.

K. Lay-in Lug Connector: Mechanical type, copper rated for direct burial terminal with set screw.

L. Service Post Connectors: Mechanical type, bronze alloy terminal, in short- and long-stud lengths, capable of single and double conductor connections.

M. Signal Reference Grid Clamp: Mechanical type, stamped-steel terminal with hex head screw.

N. Straps: Solid copper, copper lugs. Rated for 600 A.

O. Tower Ground Clamps: Mechanical type, copper or copper alloy, terminal two-piece clamp.

P. U-Bolt Clamps: Mechanical type, copper or copper alloy, terminal listed for direct burial.

Q. Water Pipe Clamps:

1. Mechanical type, two pieces with stainless-steel bolts.

a. Material: Die-cast zinc alloy.
b. Listed for direct burial.

2. U-bolt type with malleable-iron clamp and copper ground connector rated for direct burial.

2.5 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad; 3/4 inch by 10 feet.

B. Chemical-Enhanced Grounding Electrodes: Copper tube, straight or L-shaped, charged with nonhazardous electrolytic chemical salts.

1. Termination: Factory-attached No. 4/0 AWG bare conductor at least 48 inches long.
2. Backfill Material: Electrode manufacturers recommended material.

C. Ground Plates: 1/4 inch thick, hot-dip galvanized.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.

B. Underground Grounding Conductors: Install bare copper conductor, No. 2/0 AWG minimum.

1. Bury at least 24 inches below grade.
2. Duct-Bank Grounding Conductor: Bury 12 inches above duct bank when indicated as part of duct-bank installation.

C. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection,

with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.

D. Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated.

1. Install bus horizontally, on insulated spacers 2 inches minimum from wall, 6 inches above finished floor unless otherwise indicated.
2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down; connect to horizontal bus.

E. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

3.2 GROUNDING AT THE SERVICE

A. Equipment grounding conductors and grounding electrode conductors shall be connected to the ground bus. Install a main bonding jumper between the neutral and ground buses.

3.3 GROUNDING SEPARATELY DERIVED SYSTEMS

A. Generator: Install grounding electrode(s) at the generator location. The electrode shall be connected to the equipment grounding conductor and to the frame of the generator.

3.4 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

A. Comply with IEEE C2 grounding requirements.

B. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches above to 6 inches below concrete. Seal floor opening with waterproof, nonshrink grout.

C. Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 2 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches from the foundation.

3.5 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders and branch circuits.

B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:

1. Feeders and branch circuits.
2. Lighting circuits.
3. Receptacle circuits.
4. Single-phase motor and appliance branch circuits.
5. Three-phase motor and appliance branch circuits.
6. Flexible raceway runs.
7. Armored and metal-clad cable runs.

C. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.

D. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

E. Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

F. Metallic Fences: Comply with requirements of IEEE C2.

1. Grounding Conductor: Bare copper, not less than No. 8 AWG.
2. Gates: Shall be bonded to the grounding conductor with a flexible bonding jumper.
3. Barbed Wire: Strands shall be bonded to the grounding conductor.

3.6 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Ground Bonding Common with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.

C. Ground Rods: Drive rods until tops are 2 inches below finished floor or final grade unless otherwise indicated.

1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
2. Use exothermic welds for all below-grade connections.
3. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.

D. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Section 26 0543 "Underground Ducts and Raceways for Electrical Systems," and shall be at least 12 inches deep, with cover.

1. Install at least one test well for each service unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.

E. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.

F. Grounding and Bonding for Piping:

1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

G. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install tinned bonding jumper to bond across flexible duct connections to achieve continuity.

H. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet apart.

I. Concrete-Encased Grounding Electrode (Ufer Ground): Fabricate according to NFPA 70; use a minimum of 30 feet of bare copper conductor not smaller than No. 2/0 AWG.

1. If concrete foundation is less than 30 feet long, coil excess conductor within base of foundation.
2. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building's grounding grid or to grounding electrode external to concrete.

J. Concrete-Encased Grounding Electrode (Ufer Ground): Fabricate according to NFPA 70; using electrically conductive coated steel reinforcing bars or rods, at least 20 feet long. If reinforcing is in multiple pieces, connect together by the usual steel tie wires or exothermic welding to create the required length.

K. Connections: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact are galvanically compatible.

1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
2. Make connections with clean, bare metal at points of contact.
3. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.
4. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
5. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

3.7 FIELD QUALITY CONTROL

A. Testing Agency: Contractor will perform tests and inspections per NETA requirments.

B. Perform tests and inspections with the assistance of a factory-authorized service representative.

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, at ground test wells, and at individual ground rods. Make tests at ground rods before any conductors are connected.
    a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
    b. Perform tests by fall-of-potential method according to IEEE 81.
4. Prepare dimensioned Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and

their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

C. Grounding system will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

E. Report measured ground resistances that exceed the following values:

1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
2. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.
3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
4. Power Distribution Units or Panelboards Serving Electronic Equipment: 3 ohms.

F. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION 26 0526

SECTION 26 0529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Steel slotted support systems.
2. Aluminum slotted support systems.
3. Nonmetallic slotted support systems.
4. Conduit and cable support devices.
5. Support for conductors in vertical conduit.
6. Structural steel for fabricated supports and restraints.
7. Mounting, anchoring, and attachment components, including powder-actuated fasteners, mechanical expansion anchors, concrete inserts, clamps, through bolts, toggle bolts, and hanger rods.
8. Fabricated metal equipment support assemblies.

B. Related Requirements:

1. Coordinate with project's seismic requirements for products and installation requirements necessary for compliance with seismic criteria.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the following:

a. Slotted support systems, hardware, and accessories.
b. Clamps.
c. Hangers.
d. Sockets.
e. Eye nuts.
f. Fasteners.
g. Anchors.
h. Saddles.
i. Brackets.

2. Include rated capacities and furnished specialties and accessories.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. For fabrication and installation details for electrical hangers and support systems.

1. Hangers. Include product data for components.
2. Slotted support systems.
3. Equipment supports.
4. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

C. Delegated-Design Submittal: For hangers and supports for electrical systems.

1. Include design calculations and details of hangers.
2. Include design calculations for seismic restraints.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Suspended ceiling components.
2. Ductwork, piping, fittings, and supports.
3. Structural members to which hangers and supports will be attached.
4. Size and location of initial access modules for acoustical tile.
5. Items penetrating finished ceiling, including the following:

    a. Luminaires.
    b. Air outlets and inlets.
    c. Speakers.
    d. Sprinklers.
    e. Access panels.
    f. Projectors.

B. Seismic Qualification Data: Certificates, for hangers and supports for electrical equipment and systems, accessories, and components, from manufacturer for the seismic classification of this facility.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Welding certificates.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M

B. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M.
2. AWS D1.2/D1.2M.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design hanger and support system.

B. Seismic Performance: Hangers and supports shall withstand the effects of earthquake motions determined according to ASCE/SEI 7. Contractor provide per seismic classification for this project.

1. The term "withstand" means "the supported equipment and systems will remain in place without separation of any parts when subjected to the seismic forces specified and the supported equipment and systems will be fully operational after the seismic event."
2. Component Importance Factor: 1.0.

C. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame Rating: Class 1.
2. Self-extinguishing according to ASTM D 635.

2.2 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Preformed steel channels and angles with minimum 13/32-inch-diameter holes at a maximum of 8 inches o.c. in at least one surface.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include the following:

a. Allied Tube & Conduit; a part of Atkore International.
b. B-line, an Eaton business.
c. ERICO International Corporation.
d. Flex-Strut Inc.
e. GS Metals Corp.
f. G-Strut.

g. Haydon Corporation.
h. Metal Ties Innovation.
i. Thomas & Betts Corporation; A Member of the ABB Group.
j. Unistrut; Part of Atkore International.

2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.

3. Material for Channel, Fittings, and Accessories: Plain steel.

4. Channel Width: Select size pf channel width for applicable load criteria.
5. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
6. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
7. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
8. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

B. Conduit and Cable Support Devices: Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

C. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for nonarmored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be made of malleable iron.

D. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M steel plates, shapes, and bars; black and galvanized.

E. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include the following:

1) Hilti, Inc.
2) ITW Ramset/Red Head; Illinois Tool Works, Inc.
3) MKT Fastening, LLC.

2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include the following:

1) B-line, an Eaton business.
2) Empire Tool and Manufacturing Co., Inc.
3) Hilti, Inc.
4) ITW Ramset/Red Head; Illinois Tool Works, Inc.

3. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
6. Toggle Bolts: All Stainless-steel springhead type.
7. Hanger Rods: Threaded steel.

2.3 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Section 05 5000 "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with the following standards for application and installation requirements of hangers and supports, except where requirements on Drawings or in this Section are stricter:

1. NECA 1.
2. NECA 101
3. NECA 102.
4. NECA 105.
5. NECA 111.

B. Comply with requirements in Section 07 8400 "Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.

C. Comply with requirements for raceways and boxes specified in Section 26 0533 "Raceways and Boxes for Electrical Systems."

D. Maximum Support Spacing and Minimum Hanger Rod Size for Raceways: Space supports for EMT, IMC, and RMC as scheduled in NECA 1, where its Table 1 lists maximum spacing’s that are less than those stated in NFPA 70. Minimum rod size shall be 1/4 inch in diameter.

E. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with single-bolt conduit clamps using spring friction action for retention in support channel.

F. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings, and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this article.

B. Raceway Support Methods: In addition to methods described in NECA 1, EMT may be supported by openings through structure members, according to NFPA 70.

C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts.
2. To New Concrete: Bolt to concrete inserts.
3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To Existing Concrete: Expansion anchor fasteners.
5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.
6. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts, Beam clamps (MSS SP-58, Type 19, 21, 23, 25, or 27), complying with MSS SP-69.
7. To Light Steel: Sheet metal screws.
8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that comply with seismic-restraint strength and anchorage requirements.

E. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Section 05 5000 "Metal Fabrications" for site-fabricated metal supports.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

C. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 CONCRETE BASES

A. Construct concrete bases of dimensions indicated, but not less than 3 inches larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.

B. Use minimum 3000-psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Section 033000 "Cast-in-Place Concrete."

C. Anchor equipment to concrete base as follows:

1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
2. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.5 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.

B. Touchup: Comply with requirements in Section 09 9123 "Interior Painting" painting Sections for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 26 0529

SECTION 26 0533 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Metal conduits and fittings.
2. Nonmetallic conduits and fittings.
3. Metal wireways and auxiliary gutters.
4. Nonmetal wireways and auxiliary gutters.
5. Surface raceways.
6. Boxes, enclosures, and cabinets.
7. Handholes and boxes for exterior underground cabling.

B. Related Requirements:

1. Section 07 8400 "Firestopping" for firestopping at conduit and box entrances.
2. Section 26 0543 "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks, manholes, and underground utility construction.
3. Section 27 0528 "Pathways for Communications Systems" for conduits, wireways, surface pathways, innerduct, boxes, faceplate adapters, enclosures, cabinets, and handholes serving communications systems.
4. Section 28 0528 "Pathways for Electronic Safety and Security" for conduits, surface pathways, innerduct, boxes, and faceplate adapters serving electronic safety and security.

1.3 DEFINITIONS

A. ARC: Aluminum rigid conduit.

B. GRC: Galvanized rigid steel conduit.

C. IMC: Intermediate metal conduit.

1.4 ACTION SUBMITTALS

A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

B. Sustainable Design Submittals:

C. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

D. Samples: For wireways, nonmetallic wireways, surface raceways, and for each color and texture specified, 12 inches long.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:

1. Structural members in paths of conduit groups with common supports.
2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.

B. Qualification Data: For professional engineer.

C. Seismic Qualification Data: Certificates, for enclosures, cabinets, and conduit racks and their mounting provisions, including those for internal components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
4. Detailed description of conduit support devices and interconnections on which the certification is based and their installation requirements.

D. Source quality-control reports.

PART 2 - PRODUCTS

2.1 METAL CONDUITS AND FITTINGS

A. Metal Conduit:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. AFC Cable Systems; a part of Atkore International.
b. Allied Tube & Conduit; a part of Atkore International.
c. Anamet Electrical, Inc.
d. Calconduit.
e. Electri-Flex Company.
f. FSR Inc.
g. Korkap.
h. Opti-Com Manufacturing Network, Inc (OMNI).

i. O-Z/Gedney; a brand of Emerson Industrial Automation.
j. Patriot Aluminum Products, LLC.
k. Perma-Cote.
l. Picoma Industries, Inc.
m. Plasti-Bond.
n. Republic Conduit.

2. Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. GRC: Comply with ANSI C80.1 and UL 6.
4. IMC: Comply with ANSI C80.6 and UL 1242.
5. EMT: Comply with ANSI C80.3 and UL 797.

B. Metal Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. AFC Cable Systems; a part of Atkore International.
b. Allied Tube & Conduit; a part of Atkore International.
c. Anamet Electrical, Inc.
d. Calconduit.
e. Electri-Flex Company.
f. FSR Inc.
g. Korkap.
h. Opti-Com Manufacturing Network, Inc (OMNI).
i. O-Z/Gedney; a brand of Emerson Industrial Automation.
j. Patriot Aluminum Products, LLC.
k. Perma-Cote.
l. Picoma Industries, Inc.
m. Plasti-Bond.
n. Republic Conduit.

2. Comply with NEMA FB 1 and UL 514B.
3. Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
4. Fittings, General: Listed and labeled for type of conduit, location, and use.
5. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 1203 and NFPA 70.
6. Fittings for EMT:

a. Material: die cast.
b. Type: compression.

7. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.
8. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch, with overlapping sleeves protecting threaded joints.

C. Joint Compound for IMC, GRC, or ARC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 NONMETALLIC CONDUITS AND FITTINGS

A. Nonmetallic Conduit:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. AFC Cable Systems; a part of Atkore International.
    b. Anamet Electrical, Inc.
    c. Arnco Corporation.
    d. CANTEX INC.
    e. CertainTeed Corporation.
    f. Champion Fiberglass, Inc.
    g. Condux International, Inc.
    h. Electri-Flex Company.
    i. FRE Composites.
    j. Kraloy.
    k. Lamson & Sessions.
    l. Niedax Inc.
    m. RACO; Hubbell.
    n. Thomas & Betts Corporation; A Member of the ABB Group.

2. Listing and Labeling: Nonmetallic conduit shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. Fiberglass:

    a. Comply with NEMA TC 14.
    b. Comply with UL 2515 for aboveground raceways.
    c. Comply with UL 2420 for belowground raceways.

4. ENT: Comply with NEMA TC 13 and UL 1653.
5. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.
6. LFNC: Comply with UL 1660.
7. Rigid HDPE: Comply with UL 651A.
8. Continuous HDPE: Comply with UL 651A.
9. Coilable HDPE: Preassembled with conductors or cables, and complying with ASTM D 3485.
10. RTRC: Comply with UL 2515A and NEMA TC 14.

B. Nonmetallic Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. AFC Cable Systems; a part of Atkore International.
b. Anamet Electrical, Inc.
c. Arnco Corporation.
d. CANTEX INC.
e. CertainTeed Corporation.
f. Champion Fiberglass, Inc.
g. Condux International, Inc.
h. Electri-Flex Company.
i. FRE Composites.
j. Kraloy.
k. Lamson & Sessions.
l. Niedax Inc.
m. RACO; Hubbell.
n. Thomas & Betts Corporation; A Member of the ABB Group.

2. Fittings, General: Listed and labeled for type of conduit, location, and use.
3. Fittings for ENT and RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.

a. Fittings for LFNC: Comply with UL 514B.

4. Solvents and Adhesives: As recommended by conduit manufacturer.

2.3 METAL WIREWAYS AND AUXILIARY GUTTERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. B-line, an Eaton business.
2. Hoffman; a brand of Pentair Equipment Protection.
3. MonoSystems, Inc.

B. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 1, Type 3R, Type 12 unless otherwise indicated, and sized according to NFPA 70.

1. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

D. Wireway Covers: Screw-cover type, Flanged-and-casketed type in wet or damp locations unless otherwise indicated.

E. Finish: Manufacturer's standard enamel finish.

2.4 SURFACE RACEWAYS

A. Listing and Labeling: Surface raceways and tele-power poles shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Surface Metal Raceways: Galvanized steel with snap-on covers complying with UL 5. Manufacturer's standard enamel finish in color selected by Architect, or Prime coated and ready for field painting.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Hubbell Incorporated; Wiring Device-Kellems.
    b. MonoSystems, Inc.
    c. Panduit Corp.

C. Surface Nonmetallic Raceways: Two- or three-piece construction, complying with UL 5A, and manufactured of rigid PVC with texture and color selected by Architect from manufacturer's standard colors. Product shall comply with UL 94 V-0 requirements for self-extinguishing characteristics.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Hubbell Incorporated.
    b. MonoSystems, Inc.
    c. Panduit Corp.

2.5 BOXES, ENCLOSURES, AND CABINETS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Adalet.
2. Crouse-Hinds, an Eaton business.
3. EGS/Appleton Electric.
4. Erickson Electrical Equipment Company.
5. FSR Inc.
6. Hoffman; a brand of Pentair Equipment Protection.
7. Hubbell Incorporated.
8. Hubbell Incorporated; Wiring Device-Kellems.
9. Kraloy.
10. Milbank Manufacturing Co.
11. MonoSystems, Inc.
12. Oldcastle Enclosure Solutions.
13. O-Z/Gedney; a brand of Emerson Industrial Automation.
14. Plasti-Bond.

B. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.

C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, aluminum, Type FD, with gasketed cover.

E. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.

F. Metal Floor Boxes:

1. Material: Cast metal.
2. Type: Fully adjustable.
3. Shape: Rectangular.
4. Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

G. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb. Outlet boxes designed for attachment of luminaires weighing more than 50 lb shall be listed and marked for the maximum allowable weight.

H. Paddle Fan Outlet Boxes: Nonadjustable, designed for attachment of paddle fan weighing 70 lb.

1. Listing and Labeling: Paddle fan outlet boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

I. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

J. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, cast aluminum with gasketed cover.

K. Box extensions used to accommodate new building finishes shall be of same material as recessed box.

L. Device Box Dimensions: 4 inches square by 2-1/8 inches deep or 4 inches by 2-1/8 inches by 2-1/8 inches deep depending of device space requirements.

M. Gangable boxes are allowed.

N. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1, Type 3R, Type 12, with continuous-hinge cover with flush latch unless otherwise indicated.

1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
2. Nonmetallic Enclosures: Plastic.
3. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

O. Cabinets:

1. NEMA 250, Type 1, Type 3R, Type 12, galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
2. Hinged door in front cover with flush latch and concealed hinge.
3. Key latch to match panelboards.
4. Metal barriers to separate wiring of different systems and voltage.
5. Accessory feet where required for freestanding equipment.
6. Nonmetallic cabinets shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.6 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

A. General Requirements for Handholes and Boxes:

1. Boxes and handholes for use in underground systems shall be designed and identified as defined in NFPA 70, for intended location and application.
2. Boxes installed in wet areas shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel, fiberglass, or a combination of the two.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Quazite
   b. Armorcast Products Company.
   c. NewBasis.
   d. Oldcastle Enclosure Solutions.
   e. Oldcastle Precast, Inc.

2. Standard: Comply with SCTE 77.
3. Configuration: Designed for flush burial with open bottom unless otherwise indicated.
4. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
5. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
6. Cover Legend: Molded lettering, “ELECTRIC" or other systems as indicated on plans.
7. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
8. Handholes 12 Inches Wide by 12 Inches Long and Larger: Have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.7 SOURCE QUALITY CONTROL FOR UNDERGROUND ENCLOSURES

A. Handhole and Pull-Box Prototype Test: Test prototypes of handholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.

1. Tests of materials shall be performed by an independent testing agency.

2. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
3. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012 and traceable to NIST standards.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below unless otherwise indicated:

1. Exposed Conduit: GRC, Type EPC-40-PVC, Type EPC-80-PVC.
2. Concealed Conduit, Aboveground: GRC
3. Underground Conduit: RNC, Type EPC-80-PVC. Concrete encased below drive and roadways.
4. All elbows and risers shall be PVC-coated rigid galvanized steel conduit.
5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
6. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.

B. Indoors: Apply raceway products as specified below unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage: EMT.
2. Exposed, Not Subject to Severe Physical Damage: EMT identified for such use.
3. Exposed and Subject to Severe Physical Damage: GRC Raceway locations include the following:

    a. Loading dock.
    b. Mechanical rooms.

4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
6. Damp or Wet Locations: GRC.
7. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel in institutional and commercial kitchens and damp or wet locations.

C. Minimum Raceway Size: 3/4-inch trade size.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.

3. EMT: Use compression cast-metal fittings. Comply with NEMA FB 2.10.
4. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.

E. Install nonferrous conduit or tubing for circuits operating above 60 Hz. Where aluminum raceways are installed for such circuits and pass through concrete, install in nonmetallic sleeve.

F. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.

G. Install surface raceways only where indicated on Drawings.

H. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F.

3.2 INSTALLATION

A. Comply with requirements in Section 26 0529 "Hangers and Supports for Electrical Systems" for hangers and supports.

B. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum conduits. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.

C. Do not install raceways or electrical items on any "explosion-relief" walls or rotating equipment.

D. Do not fasten conduits onto the bottom side of a metal deck roof.

E. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

F. Conduits for power and special systems shall be kept separated.

1. Provide 24 inches of separation where power and special system conduits run parallel.
2. Provide 12 inches of separation where power and special system conduits cross.

G. Complete raceway installation before starting conductor installation.

H. Arrange stub-ups so curved portions of bends are not visible above finished slab.

I. Install no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within 12 inches of changes in direction.

J. Make bends in raceway using large-radius preformed ells. Field bending shall be according to NFPA 70 minimum radii requirements. Use only equipment specifically designed for material and size involved.

K. Conceal conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.

1. Mount conduit above accessible ceilings a minimum of 2 feet above the ceiling grid or tight to the structure, whichever is lower.

L. Support conduit within 12 inches of enclosures to which attached.

M. Raceways Embedded in Slabs:

1. Approval of structural engineer will be required to install any conduits in slabs. The raceways will be installed per the structural engineer's requirements. The following are minimums if structural engineer does not provide installation requirements:

   a. Run conduit larger than 1-inch trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure raceways to reinforcement at maximum 10-footintervals.
   b. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
   c. Arrange raceways to keep a minimum of 2 inches of concrete cover in all directions.
   d. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.
   a. Change from ENT to GRC before rising above floor.

N. Stub-ups to Above Recessed Ceilings:

1. Use EMT, IMC, or RMC for raceways.
2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.

O. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

P. Coat field-cut threads on PVC-coated raceway with a corrosion-preventing conductive compound prior to assembly.

Q. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors including conductors smaller than No. 4 AWG.

R. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch trade size and insulated throat metal bushings on 1-1/2-inch trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.

S. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.

T. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.

U. Cut conduit perpendicular to the length. For conduits 2-inch trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.

V. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.

W. Surface Raceways:

1. Install surface raceway with a minimum 2-inchradius control at bend points.
2. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inches and with no less than two supports per straight raceway section. Support surface raceway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.

X. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings according to NFPA 70.

Y. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where an underground service raceway enters a building or structure.
3. Conduit extending from interior to exterior of building.
4. Conduit extending into pressurized duct and equipment.
5. Conduit extending into pressurized zones that are automatically controlled to maintain different pressure set points.
6. Where otherwise required by NFPA 70.

Z. Comply with manufacturer's written instructions for solvent welding RNC and fittings.

AA. Expansion-Joint Fittings:

1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F and that has straight-run length that exceeds 25 feet. Install in each run of aboveground RMC and EMT conduit that is located where environmental temperature change may exceed 100 deg F and that has straight-run length that exceeds 100 feet.
2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:

    a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.
    b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
    c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F temperature change.
    d. Attics: 135 deg F temperature change.

3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change for PVC conduits. Install

fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F of temperature change for metal conduits.

4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

BB. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 36 inches of flexible conduit for recessed and semi-recessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

1. Use LFMC in damp or wet locations subject to severe physical damage.
2. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.

CC. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to top of outlet for installations greater than 3’-0” and to bottom of outlet for installations less than 3’-0” of box unless otherwise indicated.

DD. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.

EE. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.

FF. Locate boxes so that cover or plate will not span different building finishes.

GG. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.

HH. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

II. Set metal floor boxes level and flush with finished floor surface.

JJ. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.3 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:

1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified by division 31 for pipe less than 6 inches in nominal diameter.
2. Install backfill as specified by division 31.
3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12

inches of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified by division 31.

4. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through floor unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.
5. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through floor.
    a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete for a minimum of 12 inches on each side of the coupling.
    b. For stub-ups at equipment mounted on outdoor concrete bases and where conduits penetrate building foundations, extend steel conduit horizontally a minimum of 60 inches from edge of foundation or equipment base. Install insulated grounding bushings on terminations at equipment.
6. Warning Planks: Bury warning planks approximately 12 inches above direct-buried conduits but a minimum of 6 inches below grade. Align planks along centerline of conduit.
7. Underground Warning Tape: Comply with requirements in Section 26 0553 "Identification for Electrical Systems."

3.4 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

A. Install hand holes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.

B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch above finished grade.

D. Install hand holes with bottom below frost line at this project site. Contractor will verify frost line below grade.

E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables but short enough to preserve adequate working clearances in enclosure.

F. Field-cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

3.5 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 26 0544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.6 FIRESTOPPING

A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 07 8400 "Firestopping."

3.7 PROTECTION

A. Protect coatings, finishes, and cabinets from damage and deterioration.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 26 0533

SECTION 26 0543 - UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Metal conduits and fittings, including GRC and PVC-coated steel conduit.
2. Rigid nonmetallic duct.
3. Flexible nonmetallic duct.
4. Duct accessories.
5. Precast concrete handholes.
6. Polymer concrete handholes and boxes with polymer concrete cover.
7. Fiberglass handholes and boxes with polymer concrete cover.
8. Fiberglass handholes and boxes.
9. High-density plastic boxes.

1.3 DEFINITIONS

A. Direct Buried: Duct or a duct bank that is buried in the ground, without any additional casing materials such as concrete.

B. Duct: A single duct or multiple ducts. Duct may be either installed singly or as component of a duct bank.

C. Duct Bank:

1. Two or more ducts installed in parallel, with or without additional casing materials.
2. Multiple duct banks.

D. GRC: Galvanized rigid (steel) conduit.

E. Trafficways: Locations where vehicular or pedestrian traffic is a normal course of events.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include duct-bank materials, including spacers and miscellaneous components.

2. Include duct, conduits, and their accessories, including elbows, end bells, bends, fittings, and solvent cement.
3. Include accessories for manholes, handholes, boxes, and other utility structures.
4. Include underground-line warning tape.
5. Include warning planks.

B. Shop Drawings:

1. Precast or Factory-Fabricated Underground Utility Structures:

a. Include plans, elevations, sections, details, attachments to other work, and accessories.
b. Include duct entry provisions, including locations and duct sizes.
c. Include reinforcement details.
d. Include frame and cover design and manhole chimneys.
e. Include ladder details.
f. Include grounding details.
g. Include dimensioned locations of cable rack inserts, pulling-in and lifting irons, and sumps.
h. Include joint details.

2. Factory-Fabricated Handholes and Boxes Other Than Precast Concrete:

a. Include dimensioned plans, sections, and elevations, and fabrication and installation details.
b. Include duct entry provisions, including locations and duct sizes.
c. Include cover design.
d. Include grounding details.
e. Include dimensioned locations of cable rack inserts, and pulling-in and lifting irons.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: For duct and duct bank. Show duct profiles and coordination with other utilities and underground structures.

1. Include plans and sections, drawn to scale, and show bends and locations of expansion fittings.
2. Drawings shall be signed and sealed by a qualified professional engineer.

B. Qualification Data: For professional engineer and testing agency responsible for testing nonconcrete handholes and boxes.

C. Product Certificates: For concrete and steel used in precast concrete handholes, as required by ASTM C 858.

D. Source quality-control reports.

E. Field quality-control reports.

1.6 MAINTENANCE MATERIALS SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

B. Furnish cable-support stanchions, arms, insulators, and associated fasteners in quantities equal to 5 percent of quantity of each item installed.

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: Qualified according to ASTM E 329 for testing indicated.

1.8 FIELD CONDITIONS

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions, and then only after arranging to provide temporary electrical service according to requirements indicated:

1. Notify Architect, Construction Manager, Owner no fewer than two weeks in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without Architect's, written permission.

B. Ground Water: Assume ground-water level is at grade level unless a lower water table is noted on Drawings.

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND FITTINGS

A. GRC: Comply with ANSI C80.1 and UL 6.

B. Coated Steel Conduit: PVC-coated GRC.

1. Comply with NEMA RN 1.
2. Coating Thickness: 0.040 inch, minimum.

C. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. AFC Cable Systems; a part of Atkore International.
2. Allied Tube & Conduit; a part of Atkore International.
3. Anamet Electrical, Inc.
4. Calconduit.
5. Electri-Flex Company.
6. FSR Inc.
7. Korkap.
8. Opti-Com Manufacturing Network, Inc (OMNI).

9. O-Z/Gedney; a brand of Emerson Industrial Automation.
10. Perma-Cote.
11. Picoma Industries, Inc.
12. Plasti-Bond.
13. Republic Conduit.
14. Southwire Company.

D. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.

2.2 RIGID NONMETALLIC DUCT

A. Underground Plastic Utilities Duct: Type EPC-40-PVC RNC, complying with NEMA TC 2 and UL 651, with matching fittings complying with NEMA TC 3 by same manufacturer as duct.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ARNCO Corp.
2. Beck Manufacturing.
3. CANTEX INC.
4. CertainTeed Corporation.
5. Condux International, Inc.
6. Crown Line Plastics.
7. ElecSys, Inc.
8. Electri-Flex Company.
9. Endot Industries Inc.
10. IPEX USA LLC.
11. Lamson & Sessions.
12. Manhattan/CDT.
13. National Pipe & Plastics.
14. Opti-Com Manufacturing Network, Inc (OMNI).

C. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.

D. Solvents and Adhesives: As recommended by conduit manufacturer.

2.3 DUCT ACCESSORIES

A. Duct Spacers: Factory-fabricated, rigid, PVC interlocking spacers; sized for type and size of duct with which used, and selected to provide minimum duct spacing indicated while supporting duct during concreting or backfilling.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Allied Tube & Conduit; a part of Atkore International.
b. CANTEX INC.

c. Carlon; a brand of Thomas & Betts Corporation.
d. IPEX USA LLC.
e. PenCell Plastics.

B. Underground-Line Warning Tape: Comply with requirements for underground-line warning tape specified in Section 26 0553 "Identification for Electrical Systems."

C. Concrete Warning Planks: Nominal 12 by 24 by 3 inches in size, manufactured from 6000-psi concrete.

1. Color: Red dye added to concrete during batching.
2. Mark each plank with "ELECTRIC" in 2-inch-high, 3/8-inch-deep letters.

2.4 SOURCE QUALITY CONTROL

A. Test and inspect precast concrete utility structures according to ASTM C 1037.

B. Nonconcrete Handhole and Pull-Box Prototype Test: Test prototypes of manholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.

1. Tests of materials shall be performed by an independent testing agency.
2. Strength tests of complete boxes and covers shall be by an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
3. Testing machine pressure gages shall have current calibration certification, complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

PART 3 - EXECUTION

3.1 PREPARATION

A. Coordinate layout and installation of duct, duct bank, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field. Notify Architect if there is a conflict between areas of excavation and existing structures or archaeological sites to remain.

B. Coordinate elevations of duct and duct-bank entrances into manholes, handholes, and boxes with final locations and profiles of duct and duct banks, as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations as required to suit field conditions and to ensure that duct and duct bank will drain to manholes and handholes, and as approved by Architect.

C. Clear and grub vegetation to be removed, and protect vegetation to remain according to Division 31. Remove and stockpile topsoil for reapplication according to Division 31.

3.2 UNDERGROUND DUCT APPLICATION

A. Duct for Electrical Cables More Than 600 V: Type EPC-80-PVC RNC, concrete-encased unless otherwise indicated.

B. Duct for Electrical Feeders 600 V and Less: Type EPC-40-PVC RNC, concrete-encased unless otherwise indicated.

C. Duct for Electrical Feeders 600 V and Less: Type EPC-80-PVC RNC, direct-buried unless otherwise indicated.

D. Duct for Electrical Branch Circuits: Type EPC-40-PVC RNC, direct-buried unless otherwise indicated.

E. Underground Ducts Crossing Driveways and Roadways: Type EPC-40 PVC RNC, encased in reinforced concrete.

3.3 UNDERGROUND ENCLOSURE APPLICATION

A. Handholes and Boxes for 600 V and Less:

1. Units in Roadways and Other Deliberate Traffic Paths: Precast concrete. AASHTO HB 17, H-20 structural load rating.
2. Units in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: Precast concrete, AASHTO HB 17, H-20 structural load rating.
3. Cover design load shall not exceed the design load of the handhole or box.

3.4 EARTHWORK

A. Excavation and Backfill: Comply with Division 31 but do not use heavy-duty, hydraulic-operated, compaction equipment.

B. Restoration: Replace area after construction vehicle traffic in immediate area is complete.

C. Restore surface features at areas disturbed by excavation, and re-establish original grades unless otherwise indicated. Replace removed sod immediately after backfilling is completed.

D. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary top-soiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Comply with Section 32 9219 "Seeding" and Section 32 9300 "Plants."

E. Cut and patch existing pavement in the path of underground duct, duct bank, and underground structures according to "Cutting and Patching" Article in Section 01 7000 "Execution and Closeout Requirements."

3.5 DUCT AND DUCT-BANK INSTALLATION

A. Where indicated on Drawings, install duct, spacers, and accessories into the duct-bank configuration shown. Duct installation requirements in this Section also apply to duct bank.

B. Install duct according to NEMA TCB 2.

C. Slope: Pitch duct a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope duct from a high point between two manholes, to drain in both directions.

D. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius of 48 inches, both horizontally and vertically, at other locations unless otherwise indicated.

1. Duct shall have maximum of two 90 degree bends or the total of all bends shall be no more 180 degrees between pull points.

E. Joints: Use solvent-cemented joints in duct and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent duct do not lie in same plane.

F. Installation Adjacent to High-Temperature Steam Lines: Where duct is installed parallel to underground steam lines, perform calculations showing the duct will not be subject to environmental temperatures above 40 deg C. Where environmental temperatures are calculated to rise above 40 deg C, and anywhere the duct crosses above an underground steam line, install insulation blankets listed for direct burial to isolate the duct bank from the steam line.

G. End Bell Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately 10 inches o.c. for 5-inch duct, and vary proportionately for other duct sizes.

1. Begin change from regular spacing to end-bell spacing 10 feet from the end bell, without reducing duct slope and without forming a trap in the line.
2. Expansion and Deflection Fittings: Install an expansion and deflection fitting in each duct in the area of disturbed earth adjacent to manhole or handhole. Install an expansion fitting near the center of all straight line direct-buried duct with calculated expansion of more than 3/4 inch.
3. Grout end bells into structure walls from both sides to provide watertight entrances.

H. Terminator Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use manufactured, cast-in-place duct terminators, with entrances into structure spaced approximately 6 inches o.c. for 4-inch duct, and vary proportionately for other duct sizes.

1. Begin change from regular spacing to terminator spacing 10 feet from the terminator, without reducing duct line slope and without forming a trap in the line.
2. Expansion and Deflection Fittings: Install an expansion and deflection fitting in each duct in the area of disturbed earth adjacent to manhole or handhole. Install an expansion fitting near the center of all straight line duct with calculated expansion of more than 3/4 inch.

I. Building Wall Penetrations: Make a transition from underground duct to GRC at least 10 feet outside the building wall, without reducing duct line slope away from the building and without forming a trap in the line. Use fittings manufactured for RNC-to-GRC transition. Install GRC penetrations of building walls as specified in Section 26 0544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

J. Sealing: Provide temporary closure at terminations of duct with pulled cables. Seal spare duct at terminations. Use sealing compound and plugs to withstand at least 15-psig hydrostatic pressure.

K. Pulling Cord: Install 200-lbf-test nylon cord in empty ducts.

L. Concrete-Encased Ducts and Duct Bank:

1. Excavate trench bottom to provide firm and uniform support for duct. Prepare trench bottoms as specified by division 31 for pipes less than 6 inches in nominal diameter.
2. Width: Excavate trench 12 inches wider than duct on each side.
3. Width: Excavate trench 3 inches wider than duct on each side.
4. Depth: Install so top of duct envelope is at least 24 inches below finished grade in areas not subject to deliberate traffic, and at least 30 inches below finished grade in deliberate traffic paths for vehicles unless otherwise indicated.
5. Support duct on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.
6. Spacer Installation: Place spacers close enough to prevent sagging and deforming of duct, with not less than four spacers per 20 feet of duct. Place spacers within 24 inches of duct ends. Stagger spacers approximately 6 inches between tiers. Secure spacers to earth and to duct to prevent floating during concreting. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
7. Minimum Space between Duct: 3 inches between edge of duct and exterior envelope wall, 2 inches between ducts for like services, and 4 inches between power and communications ducts.
8. Elbows: Use manufactured duct elbows for stub-ups, at building entrances, and at changes of direction in duct unless otherwise indicated. Extend encasement throughout length of elbow.
9. Elbows: Use manufactured GRC elbows for stub-ups, at building entrances, and at changes of direction in duct run.

    a. Couple RNC duct to GRC with adapters designed for this purpose, and encase coupling with 3 inches of concrete.
    b. Stub-ups to Outdoor Equipment: Extend concrete-encased GRC horizontally a minimum of 60 inches from edge of base. Install insulated grounding bushings on terminations at equipment.

        1) Stub-ups shall be minimum 6 inches above finished floor and minimum 3 inches from conduit side to edge of slab.

    c. Stub-ups to Indoor Equipment: Extend concrete-encased GRC horizontally a minimum of 60 inches from edge of wall. Install insulated grounding bushings on terminations at equipment.

1) Stub-ups shall be minimum 6 inches above finished floor and no less than 3 inches from conduit side to edge of slab.

10. Reinforcement: Reinforce concrete-encased duct where crossing disturbed earth and where indicated. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.

11. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.
12. Concrete Cover: Install a minimum of 3 inches of concrete cover between edge of duct to exterior envelope wall, 2 inches between duct of like services, and 4 inches between power and communications ducts.
13. Concreting Sequence: Pour each run of envelope between manholes or other terminations in one continuous operation.

    a. Start at one end and finish at the other, allowing for expansion and contraction of duct as its temperature changes during and after the pour. Use expansion fittings installed according to manufacturer's written instructions, or use other specific measures to prevent expansion-contraction damage.
    b. If more than one pour is necessary, terminate each pour in a vertical plane and install 3/4-inch reinforcing-rod dowels extending a minimum of 18 inches into concrete on both sides of joint near corners of envelope.

14. Pouring Concrete: Comply with requirements in "Concrete Placement" Article in Section 03 3000 "Cast-in-Place Concrete." Place concrete carefully during pours to prevent voids under and between duct and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Allow concrete to flow around duct and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-installation application.

M. Direct-Buried Duct and Duct Bank:

1. Excavate trench bottom to provide firm and uniform support for duct. Comply with requirements by division 31 for preparation of trench bottoms for pipes less than 6 inches in nominal diameter.
2. Width: Excavate trench 12 inches wider than duct on each side.
3. Width: Excavate trench 3 inches wider than duct on each side.
4. Depth: Install top of duct at least 36 inches below finished grade unless otherwise indicated.
5. Set elevation of bottom of duct bank below frost line.
6. Support ducts on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.
7. Spacer Installation: Place spacers close enough to prevent sagging and deforming of duct, with not less than four spacers per 20 feet of duct. Place spacers within 24 inches of duct ends. Stagger spacers approximately 6 inches between tiers. Secure spacers to earth and to ducts to prevent floating during concreting. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
8. Install duct with a minimum of 3 inches between ducts for like services and 6 inches between power and communications duct.

9. Elbows: Install manufactured duct elbows for stub-ups, at building entrances, and at changes of direction in duct direction unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.
10. Install manufactured GRC elbows for stub-ups, at building entrances, and at changes of direction in duct.

    a. Couple RNC duct to GRC with adapters designed for this purpose, and encase coupling with 3 inches of concrete.
    b. Stub-ups to Outdoor Equipment: Extend concrete-encased GRC horizontally a minimum of 60 inches from edge of base. Install insulated grounding bushings on terminations at equipment.

        1) Stub-ups shall be minimum 6 inches above finished floor and minimum 3 inches from conduit side to edge of slab.

    c. Stub-ups to Indoor Equipment: Extend concrete-encased GRC horizontally a minimum of 60 inches from edge of wall. Install insulated grounding bushings on terminations at equipment.

        1) Stub-ups shall be minimum 6 inches above finished floor and no less than 3 inches from conduit side to edge of slab.

11. After installing first tier of duct, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this process. Repeat procedure after placing each tier. After placing last tier, hand place backfill to 4 inches over duct and hand tamp. Firmly tamp backfill around ducts to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct connections at end of run and complete backfilling with normal compaction. Comply with requirements in Section 312000 "Earth Moving" for installation of backfill materials.

    a. Place minimum 3 inches of sand as a bed for duct. Place sand to a minimum of 6 inches above top level of duct.
    b. Place minimum 6 inches of engineered fill above concrete encasement of duct.

N. Warning Planks: Bury warning planks approximately 12 inches above direct-buried duct, placing them 24 inches o.c. Align planks along the width and along the centerline of duct or duct bank. Provide an additional plank for each 12-inch increment of duct-bank width over a nominal 18 inches. Space additional planks 12 inches apart, horizontally.

O. Underground-Line Warning Tape: Bury conducting underground line specified in Section 26 0553 "Identification for Electrical Systems" no less than 12 inches above all concrete-encased duct and duct banks and approximately 12 inches below grade. Align tape parallel to and within 3 inches of centerline of duct bank. Provide an additional warning tape for each 12-inch increment of duct-bank width over a nominal 18 inches. Space additional tapes 12 inches apart, horizontally.

3.6 INSTALLATION OF CONCRETE HANDHOLES, AND BOXES

A. Precast Concrete Handhole Installation:

1. Comply with ASTM C 891 unless otherwise indicated.
2. Install units level and plumb and with orientation and depth coordinated with connecting duct, to minimize bends and deflections required for proper entrances.
3. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

B. Elevations:

1. Install handholes with bottom below frost line. Contractor will verify frost line at this project and depth below grade.
2. Handhole Covers: In paved areas and traffic ways, set surface flush with finished grade. Set covers of other handholes 1 inch above finished grade.
3. Where indicated, cast handhole cover frame integrally with handhole structure.

C. Drainage: Install drains in bottom of manholes where indicated. Coordinate with drainage provisions indicated.

D. Manhole Access: Circular opening in manhole roof; sized to match cover size.

1. Manholes with Fixed Ladders: Offset access opening from manhole centerlines to align with ladder.
2. Install chimney, constructed of precast concrete collars and rings, to support cast-iron frame to connect cover with manhole roof opening. Provide moisture-tight masonry joints and waterproof grouting for frame to chimney.

E. Waterproofing: Apply waterproofing to exterior surfaces of handholes after concrete has cured at least three days. Waterproofing materials and installation are specified in Section 07 1300 "Sheet Waterproofing." After duct has been connected and grouted, and before backfilling, waterproof joints and connections, and touch up abrasions and scars. Waterproof exterior of manhole chimneys after mortar has cured at least three days.

F. Damp proofing: Apply damp proofing to exterior surfaces of and handholes after concrete has cured at least three days. Damp proofing materials and installation are specified in Section 07 1113 "Bituminous Dampproofing." After ducts are connected and grouted, and before backfilling, damp proof joints and connections, and touch up abrasions and scars. Damp proof exterior of manhole chimneys after mortar has cured at least three days.

G. Hardware: Install removable hardware, including pulling eyes, cable stanchions, and cable arms, and insulators, as required for installation and support of cables and conductors and as indicated.

H. Fixed Manhole Ladders: Arrange to provide for safe entry with maximum clearance from cables and other items in manholes.

I. Field-Installed Bolting Anchors in Manholes and Concrete Handholes: Do not drill deeper than 3-7/8 inches for manholes and 2 inches for handholes, for anchor bolts installed in the field. Use a minimum of two anchors for each cable stanchion.

3.7 INSTALLATION OF HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting duct, to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of duct, and seal joint between box and extension as recommended by manufacturer.

B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas and traffic ways, set cover flush with finished grade. Set covers of other handholes 1 inch above finished grade.

D. Install handholes and boxes with bottom below frost line. Contractor will verify frost line at this project site and dimension below grade.

E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in enclosure.

F. Field cut openings for duct according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

G. For enclosures installed in asphalt paving and subject to occasional, non-deliberate, heavy-vehicle loading, form and pour a concrete ring encircling, and in contact with, enclosure and with top surface screeded to top of box cover frame. Bottom of ring shall rest on compacted earth.

1. Concrete: 3000 psi, 28-day strength, complying with Section 03 3000 "Cast-in-Place Concrete," with a troweled finish.
2. Dimensions: 10 inches wide by 12 inches deep.

3.8 GROUNDING

A. Ground underground ducts and utility structures according to Section 26 0526 "Grounding and Bonding for Electrical Systems."

3.9 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Demonstrate capability and compliance with requirements on completion of installation of underground duct, duct bank, and utility structures.
2. Pull solid aluminum or wood test mandrel through duct to prove joint integrity and adequate bend radii, and test for out-of-round duct. Provide a minimum 12-inch-long mandrel equal to duct size minus 1/4 inch. If obstructions are indicated, remove obstructions and retest.

3. Test handhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Section 26 0526 "Grounding and Bonding for Electrical Systems."

B. Correct deficiencies and retest as specified above to demonstrate compliance.

C. Prepare test and inspection reports.

3.10 CLEANING

A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of duct until duct cleaner indicates that duct is clear of dirt and debris. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.

B. Clean internal surfaces of manholes, including sump.

1. Sweep floor, removing dirt and debris.
2. Remove foreign material.

END OF SECTION 26 0543

SECTION 26 0544 - SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors.
2. Sleeve-seal systems.
3. Sleeve-seal fittings.
4. Grout.
5. Silicone sealants.

B. Related Requirements:

1. Section 07 8400 "Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 SLEEVES

A. Wall Sleeves:

1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.
2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.

C. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.

D. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.

E. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

F. Sleeves for Rectangular Openings:

1. Material: Galvanized sheet steel.
2. Minimum Metal Thickness:

a. For sleeve cross-section rectangle perimeter less than 50 inches and with no side larger than 16 inches, thickness shall be 0.052 inch.
b. For sleeve cross-section rectangle perimeter 50 inches or more and one or more sides larger than 16 inches, thickness shall be 0.138 inch.

2.2 SLEEVE-SEAL SYSTEMS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.

1. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
2. Pressure Plates: Carbon steel.
3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.3 SLEEVE-SEAL FITTINGS

A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber waterstop collar with center opening to match piping OD.

2.4 GROUT

A. Description: Non-shrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.

B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.5 SILICONE SEALANTS

A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.

1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.

B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, non-shrinking foam.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

A. Comply with NECA 1.

B. Comply with NEMA VE 2 for cable tray and cable penetrations.

C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:

1. Interior Penetrations of Non-Fire-Rated Walls and Floors:

a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 07 9200 "Joint Sealants."
b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.

2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
3. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed.
4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches above finished floor level. Install sleeves during erection of floors.

D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:

1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.

E. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing sleeve-seal system.

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.

B. Install type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.3 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout, seal the space around outside of sleeve-seal fittings.

END OF SECTION 26 0544

SECTION 26 0550 - INSTALLATION COORDINATION

PART 1 - GENERAL

1.1 REQUIREMENTS

A. See Division 21, Section 21 0549, Fire Protection and Electrical Installation Coordination.

B. See Division 22, Section 22 0549, Plumbing & Electrical Installation Coordination.

C. See Division 23, Section 23 0549, HVAC and Electrical Installation Coordination.

D. See Mechanical Drawings for control requirements and for items requiring 120V power.

PART 2 - PRODUCTS

Not applicable.

PART 3 - EXECUTION

Not applicable.

END OF SECTION 26 0550

SECTION 26 0553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Color and legend requirements for raceways, conductors, and warning labels and signs.
2. Labels.
3. Bands and tubes.
4. Tapes and stencils.
5. Tags.
6. Signs.
7. Cable ties.
8. Paint for identification.
9. Fasteners for labels and signs.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for electrical identification products.

B. Samples: For each type of label and sign to illustrate composition, size, colors, lettering style, mounting provisions, and graphic features of identification products.

C. Identification Schedule: For each piece of electrical equipment and electrical system components to be an index of nomenclature for electrical equipment and system components used in identification signs and labels. Use same designations indicated on Drawings.

D. Delegated-Design Submittal: For arc-flash hazard study.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Comply with ASME A13.1 and IEEE C2.

B. Comply with NFPA 70.

C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.

D. Comply with ANSI Z535.4 for safety signs and labels.

E. Comply with NFPA 70E and Section 260574 "Overcurrent Protective Device Arc-Flash Study" requirements for arc-flash warning labels.

F. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

G. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.

1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.

H. All boxes and enclosures, including transfer switches, generators and power panels, for emergency circuits shall be permanently marked so they will be identified as a component of the emergency circuit of system. NFPA 70, 700.9(A).

2.2 COLOR AND LEGEND REQUIREMENTS

A. Raceways and Cables Carrying Circuits at 600 V or Less:

1. Black letters on an orange field.
2. Legend: Indicate voltage and system or service type.
3. Colors: As follows:

a. 120/208 Volt – Black.
b. 277/480 Volt – Blue.
c. Emergency 120/208 Volt – Black and orange.
d. Emergency 277/480 Volt – Blue and orange.
e. Fire-Alarm System: Red.
f. Fire-Suppression Supervisory and Control System: Red and yellow.
g. Combined Fire-Alarm and Security System: Red and blue.
h. Security System: Blue and yellow.
i. Mechanical and Electrical Supervisory System: Green and blue.
j. Data System: Green and yellow.
k. Television Systems: Green and White.
l. Sound/PA: Orange.
m. Telephone: Orange and yellow.

B. Color-Coding for Phase and Voltage-Level Identification, 600 V or Less: Use colors listed below for ungrounded service, feeder, and branch-circuit, conductors.

1. Color shall be factory applied No. 12 AWG.
2. Colors for 208/120-V Circuits:

a. Phase A: Black.
b. Phase B: Red.
c. Phase C: Blue.

3. Colors for 240-V Circuits:

    a. Phase A: Black.
    b. Phase B: Red.

4. Colors for 480/277-V Circuits:

    a. Phase A: Brown.
    b. Phase B: Orange.
    c. Phase C: Yellow.

5. Color for Neutral: White.
6. Color for Equipment Grounds: Green.
7. Colors for Isolated Grounds: Green with white stripe.

C. Raceways and Cables Carrying Circuits at More Than 600 V:

1. Black letters on an orange field.
2. Legend: "DANGER - CONCEALED HIGH VOLTAGE WIRING."

D. Warning Label Colors:

1. Identify system voltage with black letters on an orange background.

E. Warning labels and signs shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."

F. Equipment Identification Labels:

1. Black letters on a white field.
2. Label all electrical distribution equipment down to 100A.

2.3 LABELS

A. Vinyl Wraparound Labels: Preprinted, flexible labels laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Brady Corporation.
    b. Champion America.
    c. emedco.
    d. Grafoplast Wire Markers.
    e. HellermannTyton.
    f. LEM Products Inc.

g. Marking Services, Inc.
h. Panduit Corp.

B. Snap-around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameters sized to suit diameters and that stay in place by gripping action.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Brady Corporation.
b. HellermannTyton.
c. Marking Services, Inc.
d. Panduit Corp.

C. Self-Adhesive Wraparound Labels: Preprinted, 3-mil-thick, vinyl flexible label with acrylic pressure-sensitive adhesive.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. A'n D Cable Products.
b. Brady Corporation.
c. Brother International Corporation.
d. emedco.
e. Grafoplast Wire Markers.
f. Ideal Industries, Inc.
g. LEM Products Inc.
h. Marking Services, Inc.
i. Panduit Corp.

2. Self-Lamination: Clear; UV-, weather- and chemical-resistant; self-laminating, protective shield over the legend. Labels sized such that the clear shield overlaps the entire printed legend.
3. Marker for Labels: Permanent, waterproof, black ink marker recommended by tag manufacturer.
4. Marker for Labels: Machine-printed, permanent, waterproof, black ink recommended by printer manufacturer.

D. Self-Adhesive Labels: Vinyl, thermal, transfer-printed, 3-mil-thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. A'n D Cable Products.
b. Brady Corporation.
c. Brother International Corporation.
d. emedco.
e. Grafoplast Wire Markers.
f. HellermannTyton.
g. Ideal Industries, Inc.

h. LEM Products Inc.
i. Marking Services, Inc.
j. Panduit Corp.

2. Minimum Nominal Size:

a. 1-1/2 by 6 inches for raceway and conductors.
b. 3-1/2 by 5 inches for equipment.
c. As required by authorities having jurisdiction.

2.4 BANDS AND TUBES

A. Snap-around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inches long, with diameters sized to suit diameters and that stay in place by gripping action.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Brady Corporation.
b. HellermannTyton.
c. Marking Services, Inc.

B. Heat-Shrink Preprinted Tubes: Flame-retardant polyolefin tubes with machine-printed identification labels, sized to suit diameter and shrunk to fit firmly. Full shrink recovery occurs at a maximum of 200 deg F. Comply with UL 224.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. Brady Corporation.

2.5 TAPES AND STENCILS

A. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Carlton Industries, LP.
b. Champion America.
c. HellermannTyton.
d. Ideal Industries, Inc.
e. Marking Services, Inc.

B. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; not less than 3 mils thick by 1 to 2 inches wide; compounded for outdoor use.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Brady Corporation.
    b. Carlton Industries, LP.
    c. emedco.

C. Tape and Stencil: 4-inch-wide black stripes on 10-inch centers placed diagonally over orange background and is 12 inches wide. Stop stripes at legends.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. HellermannTyton.
    b. LEM Products Inc.
    c. Marking Services, Inc.

D. Floor Marking Tape: 2-inch-wide, 5-mil pressure-sensitive vinyl tape, with black and white stripes and clear vinyl overlay.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

    a. Carlton Industries, LP.

E. Underground-Line Warning Tape:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Brady Corporation.
    b. Ideal Industries, Inc.
    c. LEM Products Inc.
    d. Marking Services, Inc.
    e. Reef Industries, Inc.

2. Tape:

    a. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
    b. Printing on tape shall be permanent and shall not be damaged by burial operations.
    c. Tape material and ink shall be chemically inert and not subject to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.

3. Color and Printing:

    a. Comply with ANSI Z535.1, ANSI Z535.2, ANSI Z535.3, ANSI Z535.4, and ANSI Z535.5.
    b. Inscriptions for Red-Colored Tapes: "ELECTRIC LINE, HIGH VOLTAGE"

c. Inscriptions for Orange-Colored Tapes: "TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE".

4. Tag: Type II:

a. Multilayer laminate, consisting of high-density polyethylene scrim coated with pigmented polyolefin; bright colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
b. Width: 3 inches.
c. Thickness: 12 mils.
d. Weight: 36.1 lb/1000 sq. ft.
e. Tensile according to ASTM D 882: 400 lbf and 11,500 psi.

F. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height shall be 1 inch.

2.6 TAGS

A. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch, with stamped legend, punched for use with self-locking cable tie fastener.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Brady Corporation.
b. Carlton Industries, LP.
c. emedco.
d. Marking Services, Inc.

B. Nonmetallic Preprinted Tags: Polyethylene tags, 0.015 inch thick, color-coded for phase and voltage level, with factory printed permanent designations; punched for use with self-locking cable tie fastener.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Brady Corporation.
b. Carlton Industries, LP.
c. emedco.
d. Grafoplast Wire Markers.
e. LEM Products Inc.
f. Marking Services, Inc.
g. Panduit Corp.

C. Write-on Tags:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Carlton Industries, LP.

b. LEM Products Inc.

2. Polyester Tags: 0.015 inch thick, with corrosion-resistant grommet and cable tie for attachment.
3. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
4. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.7 SIGNS

A. Baked-Enamel Signs:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Carlton Industries, LP.
   b. Champion America.
   c. emedco.

2. Preprinted aluminum signs, high-intensity reflective, punched or drilled for fasteners, with colors, legend, and size required for application.
3. 1/4-inch grommets in corners for mounting.
4. Nominal Size: 7 by 10 inches.

B. Metal-Backed Butyrate Signs:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Brady Corporation.
   b. Champion America.
   c. emedco.

2. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs, with 0.0396-inch galvanized-steel backing, punched and drilled for fasteners, and with colors, legend, and size required for application.
3. 1/4-inch grommets in corners for mounting.
4. Nominal Size: 10 by 14 inches.

C. Laminated Acrylic or Melamine Plastic Signs:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Brady Corporation.
   b. Carlton Industries, LP.
   c. emedco.

2. Engraved legend.

3. Thickness:

    a. For signs up to 20 sq. in., minimum 1/16 inch thick.
    b. For signs larger than 20 sq. in., 1/8 inch thick.
    c. Engraved legend with Black letters on white face.
    d. Punched or drilled for mechanical fasteners with 1/4-inch grommets in corners for mounting.
    e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.8 CABLE TIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. HellermannTyton.
2. Ideal Industries, Inc.
3. Marking Services, Inc.

B. General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 Deg F according to ASTM D 638: 12,000 psi.
3. Temperature Range: Minus 40 to plus 185 deg F.
4. Color: Black, except where used for color-coding.

C. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 Deg F according to ASTM D 638: 12,000 psi.
3. Temperature Range: Minus 40 to plus 185 deg F.
4. Color: Black.

D. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, and self-locking.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 Deg F according to ASTM D 638: 7000 psi.
3. UL 94 Flame Rating: 94V-0.
4. Temperature Range: Minus 50 to plus 284 deg F.
5. Color: Black.

2.9 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 PREPARATION

A. Self-Adhesive Identification Products: Before applying electrical identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

3.2 INSTALLATION

A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.

B. Install identifying devices before installing acoustical ceilings and similar concealment.

C. Verify identity of each item before installing identification products.

D. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.

E. Apply identification devices to surfaces that require finish after completing finish work.

F. Install signs with approved legend to facilitate proper identification, operation, and maintenance of electrical systems and connected items.

G. System Identification for Raceways and Cables under 600 V: Identification shall completely encircle cable or conduit. Place identification of two-color markings in contact, side by side.

1. Secure tight to surface of conductor, cable, or raceway.

H. System Identification for Raceways and Cables over 600 V: Identification shall completely encircle cable or conduit. Place adjacent identification of two-color markings in contact, side by side.

1. Secure tight to surface of conductor, cable, or raceway.

I. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.

J. Stand-By Power Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch-high letters for emergency instructions at equipment used for power transfer.

K. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from the floor.

L. Accessible Fittings for Raceways: Identify the covers of each junction and pull box of the following systems with the wiring system legend and system voltage. System legends shall be as follows:

1. "POWER."
2. “STAND-BY POWER”

M. Vinyl Wraparound Labels:

1. Secure tight to surface of raceway or cable at a location with high visibility and accessibility.
2. Attach labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to the location and substrate.

N. Snap-around Labels: Secure tight to surface at a location with high visibility and accessibility.

O. Self-Adhesive Wraparound Labels: Secure tight to surface at a location with high visibility and accessibility.

P. Self-Adhesive Labels:

1. On each item, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on 1-1/2-inch-high label; where two lines of text are required, use labels 2 inches high.

Q. Snap-around Color-Coding Bands: Secure tight to surface at a location with high visibility and accessibility.

R. Heat-Shrink, Preprinted Tubes: Secure tight to surface at a location with high visibility and accessibility.

S. Marker Tapes: Secure tight to surface at a location with high visibility and accessibility.

T. Self-Adhesive Vinyl Tape: Secure tight to surface at a location with high visibility and accessibility.

1. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding.

U. Tape and Stencil: Comply with requirements in painting Sections for surface preparation and paint application.

V. Floor Marking Tape: Apply stripes to finished surfaces following manufacturer's written instructions.

W. Underground Line Warning Tape:

1. During backfilling of trenches, install continuous underground-line warning tape directly above cable or raceway at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches overall.
2. Limit use of underground-line warning tape to direct-buried cables.
3. Install underground-line warning tape for direct-buried cables and cables in raceways.

X. Metal Tags:

1. Place in a location with high visibility and accessibility.
2. Secure using plenum-rated cable ties.

Y. Nonmetallic Preprinted Tags:

1. Place in a location with high visibility and accessibility.
2. Secure using plenum-rated cable ties.

Z. Write-on Tags:

1. Place in a location with high visibility and accessibility.
2. Secure using plenum-rated cable ties.

AA. Baked-Enamel Signs:

1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on minimum 1-1/2-inch-high sign; where two lines of text are required, use signs minimum 2 inches high.

BB. Metal-Backed Butyrate Signs:

1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on 1-1/2-inch-high sign; where two lines of text are required, use labels 2 inches high.

CC. Laminated Acrylic or Melamine Plastic Signs:

1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on 1-1/2-inch-high sign; where two lines of text are required, use labels 2 inches high.

DD. Cable Ties: General purpose, for attaching tags, except as listed below:

1. Outdoors: UV-stabilized nylon.
2. In Spaces Handling Environmental Air: Plenum rated.

3.3 IDENTIFICATION SCHEDULE

A. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.

B. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations of high visibility. Identify by system and circuit designation.

C. Concealed Raceways, Duct Banks, More Than 600 V, within Buildings: Tape and stencil. Stencil legend "DANGER - CONCEALED HIGH-VOLTAGE WIRING" with 3-inch-high, black letters on 20-inch centers.

1. Locate identification at changes in direction, at penetrations of walls and floors, and at 10-foot maximum intervals.

D. Accessible Fittings for Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive labels containing the wiring system legend and system voltage. System legends shall be as follows:

1. "POWER."

E. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use snap-around color-coding bands to identify the phase.

1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.

F. Power-Circuit Conductor Identification, More Than 600 V: For conductors in vaults, pull and junction boxes, manholes, and handholes, use nonmetallic preprinted tags colored and marked to indicate phase, and a separate tag with the circuit designation.

G. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes, manholes, and handholes, use self-adhesive labels with the conductor or cable designation, origin, and destination.

H. Control-Circuit Conductor Termination Identification: For identification at terminations, provide self-adhesive labels with the conductor designation.

I. Conductors to Be Extended in the Future: Attach marker tape to conductors and list source.

J. Auxiliary Electrical Systems Conductor Identification: Self-adhesive vinyl tape that is uniform and consistent with system used by manufacturer for factory-installed connections.

1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.

K. Locations of Underground Lines: Underground-line warning tape for power, lighting, communication, and control wiring and optical-fiber cable.

L. Concealed Raceways and Duct Banks, More Than 600 V, within Buildings: Apply floor marking tape to the following finished surfaces:

1. Floor surface directly above conduits running beneath and within 12 inches of a floor that is in contact with earth or is framed above unexcavated space.
2. Wall surfaces directly external to raceways concealed within wall.
3. Accessible surfaces of concrete envelope around raceways in vertical shafts, exposed in the building, or concealed above suspended ceilings.

M. Workspace Indication: Apply floor marking tape to finished surfaces. Show working clearances in the direction of access to live parts. Workspace shall comply with NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

N. Instructional Signs: Self-adhesive labels, including the color code for grounded and ungrounded conductors.

O. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Baked-enamel warning signs.

1. Apply to exterior of door, cover, or other access.
2. For equipment with multiple power or control sources, apply to door or cover of equipment, including, but not limited to, the following:

    a. Power-transfer switches.
    b. Controls with external control power connections.

P. Arc Flash Warning Labeling: Self-adhesive labels.

Q. Operating Instruction Signs: Laminated acrylic or melamine plastic signs.

R. Equipment Identification Labels:

1. Install identification as follows:

2. Apply equipment identification labels of engraved plastic laminate on each major unit of equipment, including central or master unit of each system. This includes communication, signal, and alarm systems, unless units are specified with their own self-explanatory identification. Except as otherwise indicated, provide a single line of text with 1/2-inch high lettering on 1-1/2-inch high label; where 2 lines of text are required, use lettering 2 inches high. Use white lettering on black field. Apply labels for each unit of the following categories of equipment.
   Example: *Panel 1H1 120/208V, 3-PH, 4-wire, AIC, Amperage, fed from panel MDR-CCT#4.*
3. Indoor Equipment: Laminated acrylic or melamine plastic sign.
4. Outdoor Equipment: Laminated acrylic or melamine sign.
5. Equipment to Be Labeled:

    a. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be in the form of a engraved, laminated acrylic or melamine label.

b. Enclosures and electrical cabinets.
c. Access doors and panels for concealed electrical items.
d. Switchgear.
e. Switchboards.
f. Transformers: Label that includes tag designation indicated on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.
g. Substations.
h. Emergency system boxes and enclosures.
i. Motor-control centers.
j. Enclosed switches.
k. Enclosed circuit breakers.
l. Enclosed controllers.
m. Variable-speed controllers.
n. Push-button stations.
o. Power-transfer equipment.
p. Contactors.
q. Remote-controlled switches, dimmer modules, and control devices.
r. Battery-inverter units.
s. Battery racks.
t. Power-generating units.
u. Monitoring and control equipment.
v. UPS equipment.

6. Circuits: Apply identification labels of engraved plastic laminate on each switch and receptacle indicating panelboard and circuit number supplying receptacle. Handwrite circuit behind cover plate.
7. Apply designation labels of engraved plastic laminate for disconnect switches, breakers, push buttons, pilot lights, motor control centers, and similar items for power distribution and control components above, except panelboards and alarm/signal components where labeling is specified elsewhere. For panelboards, provide framed, typed circuit schedules with explicit description and identification of items controlled by each individual breaker.

END OF SECTION 26 0553

SECTION 26 0572 - OVERCURRENT PROTECTIVE DEVICE SHORT-CIRCUIT STUDY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes a computer-based, fault-current study to determine the minimum interrupting capacity of circuit protective devices.

1.3 DEFINITIONS

A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

B. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.

C. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.

D. SCCR: Short-circuit current rating.

E. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

1.4 ACTION SUBMITTALS

A. Product Data: For computer software program to be used for studies.

B. Other Action Submittals: Submit the following after the approval of system protective devices submittals. Submittals shall be in digital form.

1. Short-circuit study input data, including completed computer program input data sheets.
2. Short-circuit study and equipment evaluation report; signed, dated, and sealed by a qualified professional engineer.

a. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.

b. Revised single-line diagram, reflecting field investigation results and results of short-circuit study.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Short-Circuit Study Specialist.

B. Product Certificates: For short-circuit study software, certifying compliance with IEEE 399.

1.6 QUALITY ASSURANCE

A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are unacceptable.

B. Short-Circuit Study Software Developer Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.

1. The computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.

C. Short-Circuit Study Specialist Qualifications: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

D. Field Adjusting Agency Qualifications: An independent agency, with the experience and capability to adjust overcurrent devices and to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. CGI CYME.
2. EDSA Micro Corporation.
3. ESA Inc.
4. Operation Technology, Inc.
5. Power Analytics, Corporation.

B. Comply with IEEE 399 and IEEE 551.

C. Analytical features of fault-current-study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

D. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output.

2.2 SHORT-CIRCUIT STUDY REPORT CONTENTS

A. Executive summary.

B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of the computer printout.

C. One-line diagram, showing the following:

1. Protective device designations and ampere ratings.
2. Cable size and lengths.
3. Transformer kilovolt ampere (kVA) and voltage ratings.
4. Motor and generator designations and kVA ratings.
5. Switchgear, switchboard, motor-control center, and panelboard designations.

D. Comments and recommendations for system improvements, where needed.

E. Protective Device Evaluation:

1. Evaluate equipment and protective devices and compare to short-circuit ratings.
2. Tabulations of circuit breaker, fuse, and other protective device ratings versus calculated short-circuit duties.
3. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
4. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in the standards to 1/2-cycle symmetrical fault current.
5. Verify adequacy of phase conductors at maximum three-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure that short-circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.

F. Short-Circuit Study Input Data: As described in "Power System Data" Article in the Evaluations.

G. Short-Circuit Study Output:

1. Low-Voltage Fault Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

a. Voltage.
b. Calculated fault-current magnitude and angle.
c. Fault-point X/R ratio.

d. Equivalent impedance.

2. Momentary Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

a. Voltage.
b. Calculated symmetrical fault-current magnitude and angle.
c. Fault-point X/R ratio.
d. Calculated asymmetrical fault currents:

1) Based on fault-point X/R ratio.
2) Based on calculated symmetrical value multiplied by 1.6.
3) Based on calculated symmetrical value multiplied by 2.7.

3. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

a. Voltage.
b. Calculated symmetrical fault-current magnitude and angle.
c. Fault-point X/R ratio.
d. No AC Decrement (NACD) ratio.
e. Equivalent impedance.
f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Obtain all data necessary for the conduct of the study.

1. Verify completeness of data supplied on the one-line diagram. Call any discrepancies to the attention of Architect.
2. For equipment provided that is Work of this Project, use characteristics submitted under the provisions of action submittals and information submittals for this Project.

B. Gather and tabulate the following input data to support the short-circuit study. Comply with recommendations in IEEE 551 as to the amount of detail that is required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.

1. Product Data for Project's overcurrent protective devices involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Obtain electrical power utility impedance at the service.
3. Power sources and ties.

4. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
5. For reactors, provide manufacturer and model designation, voltage rating, and impedance.
6. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip, SCCR, current rating, and breaker settings.
7. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
8. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
9. Motor horsepower and NEMA MG 1 code letter designation.
10. Cable sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).

3.2 SHORT-CIRCUIT STUDY

A. Perform study following the general study procedures contained in IEEE 399.

B. Calculate short-circuit currents according to IEEE 551.

C. Base study on the device characteristics supplied by device manufacturer.

D. The extent of the electrical power system to be studied is indicated on Drawings.

E. Begin short-circuit current analysis at the service, extending down to the system overcurrent protective devices as follows:

1. To normal system low-voltage load buses where fault current is 10 kA or less.
2. Exclude equipment rated 240-V ac or less when supplied by a single transformer rated less than 125 kVA.

F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.

G. The calculations shall include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and shall apply to low- and medium-voltage, three-phase ac systems. The calculations shall also account for the fault-current dc decrement, to address the asymmetrical requirements of the interrupting equipment.

1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.

H. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault at each of the following:

1. Electric utility's supply termination point.
2. Incoming switchgear.
3. Unit substation primary and secondary terminals.
4. Low-voltage switchgear.

5. Motor-control centers.
6. Control panels.
7. Standby generators and automatic transfer switches.
8. Branch circuit panelboards.
9. Disconnect switches.

3.3 ADJUSTING

A. Make minor modifications to equipment as required to accomplish compliance with short-circuit study.

3.4 DEMONSTRATION

A. Train Owner's operating and maintenance personnel in the use of study results.

END OF SECTION 26 0572

SECTION 26 0573 - OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes computer-based, overcurrent protective device coordination studies to determine overcurrent protective devices and to determine overcurrent protective device settings for selective tripping.

1. Study results shall be used to determine coordination of series-rated devices.

1.3 DEFINITIONS

A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

B. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.

C. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.

D. SCCR: Short-circuit current rating.

E. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

1.4 ACTION SUBMITTALS

A. Product Data: For computer software program to be used for studies.

B. Other Action Submittals: Submit the following after the approval of system protective devices submittals. Submittals shall be in digital form.

1. Coordination-study input data, including completed computer program input data sheets.
2. Study and equipment evaluation reports.
3. Overcurrent protective device coordination study report; signed, dated, and sealed by a qualified professional engineer.

a. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Coordination Study Specialist.

B. Product Certificates: For overcurrent protective device coordination study software, certifying compliance with IEEE 399.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For the overcurrent protective devices to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 01 7800 "Closeout Submittals" include the following:

a. The following parts from the Protective Device Coordination Study Report:

1) One-line diagram.
2) Protective device coordination study.
3) Time-current coordination curves.

b. Power system data.

1.7 QUALITY ASSURANCE

A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are unacceptable.

B. Coordination Study Software Developer Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.

1. The computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.

C. Coordination Study Specialist Qualifications: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

D. Field Adjusting Agency Qualifications: An independent agency, with the experience and capability to adjust overcurrent devices and to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

A. Software Developers:

1. SKM

B. Comply with IEEE 242 and IEEE 399.

C. Analytical features of device coordination study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

D. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, time-current coordination plots.

1. Optional Features:

a. Arcing faults.
b. Simultaneous faults.
c. Explicit negative sequence.
d. Mutual coupling in zero sequence.

2.2 PROTECTIVE DEVICE COORDINATION STUDY REPORT CONTENTS

A. Executive summary.

B. Study descriptions, purpose, basis and scope. Include case descriptions, definition of terms and guide for interpretation of the computer printout.

C. One-line diagram, showing the following:

1. Protective device designations and ampere ratings.
2. Cable size and lengths.
3. Transformer kilovolt ampere (kVA) and voltage ratings.
4. Motor and generator designations and kVA ratings.
5. Switchgear, switchboard, motor-control center, and panelboard designations.

D. Study Input Data: As described in "Power System Data" Article.

E. Short-Circuit Study Output: As specified in "Short-Circuit Study Output" Paragraph in "Short-Circuit Study Report Contents" Article in Section 26 0572 "Overcurrent Protective Device Short-Circuit Study."

F. Protective Device Coordination Study:

1. Report recommended settings of protective devices, ready to be applied in the field. Use manufacturer's data sheets for recording the recommended setting of overcurrent protective devices when available.

    a. Phase and Ground Relays:

        1) Device tag.
        2) Relay current transformer ratio and tap, time dial, and instantaneous pickup value.
        3) Recommendations on improved relaying systems, if applicable.

    b. Circuit Breakers:

        1) Adjustable pickups and time delays (long time, short time, ground).
        2) Adjustable time-current characteristic.
        3) Adjustable instantaneous pickup.
        4) Recommendations on improved trip systems, if applicable.

    c. Fuses: Show current rating, voltage, and class.

G. Time-Current Coordination Curves: Determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:

1. Device tag and title, one-line diagram with legend identifying the portion of the system covered.
2. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.
3. Identify the device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.
4. Plot the following listed characteristic curves, as applicable:

    a. Power utility's overcurrent protective device.
    b. Medium-voltage equipment overcurrent relays.
    c. Medium- and low-voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
    d. Low-voltage equipment circuit-breaker trip devices, including manufacturer's tolerance bands.
    e. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves.
    f. Cables and conductors damage curves.
    g. Ground-fault protective devices.
    h. Motor-starting characteristics and motor damage points.

i. Generator short-circuit decrement curve and generator damage point.
j. The largest feeder circuit breaker in each motor-control center and panelboard.

5. Series rating on equipment allows the application of two series interrupting devices for a condition where the available fault current is greater than the interrupting rating of the downstream equipment. Both devices share in the interruption of the fault and selectivity is sacrificed at high fault levels. Maintain selectivity for tripping currents caused by overloads.
6. Provide adequate time margins between device characteristics such that selective operation is achieved.
7. Comments and recommendations for system improvements.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Devices to be coordinated are indicated on Drawings.

1. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.

3.2 PROTECTIVE DEVICE COORDINATION STUDY

A. Comply with IEEE 242 for calculating short-circuit currents and determining coordination time intervals.

B. Comply with IEEE 399 for general study procedures.

C. The study shall be based on the device characteristics supplied by device manufacturer.

D. The extent of the electrical power system to be studied is indicated on Drawings.

E. Begin analysis at the service, extending down to the system overcurrent protective devices as follows:

1. To normal system low-voltage load buses where fault current is 10 kA or less.
2. Exclude equipment rated 240-V ac or less when supplied by a single transformer rated less than 125 kVA.

F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.

G. Transformer Primary Overcurrent Protective Devices:

1. Device shall not operate in response to the following:

    a. Inrush current when first energized.
    b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
    c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.

2. Device settings shall protect transformers according to IEEE C57.12.00, for fault currents.

H. Motor Protection:

1. Select protection for low-voltage motors according to IEEE 242 and NFPA 70.
2. Select protection for motors served at voltages more than 600 V according to IEEE 620.

I. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and protection recommendations in IEEE 242. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.

J. Generator Protection: Select protection according to manufacturer's written recommendations and to IEEE 242.

K. The calculations shall include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and shall apply to low- and medium-voltage, three-phase ac systems. The calculations shall also account for the fault-current dc decrement, to address the asymmetrical requirements of the interrupting equipment.

1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.

L. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and single line-to-ground fault at each of the following:

1. Electric utility's supply termination point.
2. Switchgear.
3. Low-voltage switchgear.
4. Standby generators and automatic transfer switches.
5. Branch circuit panelboards.

M. Protective Device Evaluation:

1. Evaluate equipment and protective devices and compare to short-circuit ratings.
2. Adequacy of switchgear, motor-control centers, and panelboard bus bars to withstand short-circuit stresses.
3. Any application of series-rated devices shall be recertified, complying with requirements in NFPA 70.

3.3 LOAD-FLOW AND VOLTAGE-DROP STUDY

A. Perform a load-flow and voltage-drop study to determine the steady-state loading profile of the system. Analyze power system performance two times as follows:

1. Determine load-flow and voltage drop based on full-load currents obtained in "Power System Data" Article.
2. Determine load-flow and voltage drop based on 80 percent of the design capacity of the load buses.
3. Prepare the load-flow and voltage-drop analysis and report to show power system components that are overloaded, or might become overloaded; show bus voltages that are less than as prescribed by NFPA 70.

3.4 MOTOR-STARTING STUDY

A. Perform a motor-starting study to analyze the transient effect of the system's voltage profile during motor starting. Calculate significant motor-starting voltage profiles and analyze the effects of the motor starting on the power system stability.

B. Prepare the motor-starting study report, noting light flicker for limits proposed by IEEE 141, and voltage sags so as not to affect the operation of other utilization equipment on the system supplying the motor.

3.5 POWER SYSTEM DATA

A. Obtain all data necessary for the conduct of the overcurrent protective device study.

1. Verify completeness of data supplied in the one-line diagram on Drawings. Call discrepancies to the attention of Architect.
2. For new equipment, use characteristics submitted under the provisions of action submittals and information submittals for this Project.
3. For existing equipment, whether or not relocated obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers. The qualifications of technicians and engineers shall be qualified as defined by NFPA 70E.

B. Gather and tabulate the following input data to support coordination study. The list below is a guide. Comply with recommendations in IEEE 551 for the amount of detail required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.

1. Product Data for overcurrent protective devices specified in other Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Electrical power utility impedance at the service.
3. Power sources and ties.

4. Short-circuit current at each system bus, three phase and line-to-ground.
5. Full-load current of all loads.
6. Voltage level at each bus.
7. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
8. For reactors, provide manufacturer and model designation, voltage rating, and impedance.
9. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
10. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
11. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.
12. Maximum demands from service meters.
13. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
14. Motor horsepower and NEMA MG 1 code letter designation.
15. Low-voltage cable sizes, lengths, number, conductor material, and conduit material (magnetic or nonmagnetic).
16. Medium-voltage cable sizes, lengths, conductor material, and cable construction and metallic shield performance parameters.
17. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram, showing the following:

    a. Special load considerations, including starting inrush currents and frequent starting and stopping.
    b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.
    c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
    d. Generator thermal-damage curve.
    e. Ratings, types, and settings of utility company's overcurrent protective devices.
    f. Special overcurrent protective device settings or types stipulated by utility company.
    g. Time-current-characteristic curves of devices indicated to be coordinated.
    h. Manufacturer, frame size, interrupting rating in amperes rms symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
    i. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
    j. Panelboards, switchboards, motor-control center ampacity, and SCCR in amperes rms symmetrical.
    k. Identify series-rated interrupting devices for a condition where the available fault current is greater than the interrupting rating of the downstream equipment. Obtain device data details to allow verification that series application of these devices complies with NFPA 70 and UL 489 requirements.

3.6 FIELD ADJUSTING

A. Adjust relay and protective device settings according to the recommended settings provided by the coordination study. Field adjustments shall be completed by the engineering service division of the equipment manufacturer under the Startup and Acceptance Testing contract portion.

B. Make minor modifications to equipment as required to accomplish compliance with short-circuit and protective device coordination studies.

C. Testing and adjusting shall be by a full-time employee of the Field Adjusting Agency, who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters. Perform NETA tests and inspections for all adjustable overcurrent protective devices.

3.7 DEMONSTRATION

A. Engage the Coordination Study Specialist to train Owner's maintenance personnel in the following:

1. Acquaint personnel in the fundamentals of operating the power system in normal and emergency modes.
2. Hand-out and explain the objectives of the coordination study, study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpreting the time-current coordination curves.
3. Adjust, operate, and maintain overcurrent protective device settings.

END OF SECTION 26 0573

SECTION 26 0574 - OVERCURRENT PROTECTIVE DEVICE ARC-FLASH STUDY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes a computer-based, arc-flash study to determine the arc-flash hazard distance and the incident energy to which personnel could be exposed during work on or near electrical equipment.

1.3 DEFINITIONS

A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

B. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.

C. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.

D. SCCR: Short-circuit current rating.

E. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

1.4 ACTION SUBMITTALS

A. Product Data: For computer software program to be used for studies.

B. Study Submittals: Submit the following submittals after the approval of system protective devices submittals. Submittals shall be in digital form.

1. Arc-flash study input data, including completed computer program input data sheets.
2. Arc-flash study report; signed, dated, and sealed by a qualified professional engineer.

a. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary

submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Arc-Flash Study Specialist.

B. Product Certificates: For arc-flash hazard analysis software, certifying compliance with IEEE 1584 and NFPA 70E.

Commented [JMM1]:

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data:

1. Maintenance procedures according to requirements in NFPA 70E shall be provided in the equipment manuals.
2. Operation and Maintenance Procedures: In addition to items specified in Section 01 7800 "Closeout Submittals" provide maintenance procedures for use by Owner's personnel that comply with requirements in NFPA 70E.

1.7 QUALITY ASSURANCE

A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are unacceptable.

B. Arc-Flash Study Software Developer Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.

1. The computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.

C. Arc-Flash Study Specialist Qualifications: Professional engineer in charge of performing the study, analyzing the arc flash, and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

D. Field Adjusting Agency Qualifications: An independent agency, with the experience and capability to adjust overcurrent devices and to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. CGI CYME.
2. EDSA Micro Corporation.
3. ESA Inc.
4. Operation Technology, Inc.
5. Power Analytics, Corporation.

B. Comply with IEEE 1584 and NFPA 70E.

C. Analytical features of device coordination study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

2.2 ARC-FLASH STUDY REPORT CONTENT

A. Executive summary.

B. Study descriptions, purpose, basis and scope.

C. One-line diagram, showing the following:

1. Protective device designations and ampere ratings.
2. Cable size and lengths.
3. Transformer kilovolt ampere (kVA) and voltage ratings.
4. Motor and generator designations and kVA ratings.
5. Switchgear, switchboard, motor-control center and panelboard designations.

D. Study Input Data: As described in "Power System Data" Article.

E. Short-Circuit Study Output: As specified in "Short Circuit Study Output" Paragraph in "Short-Circuit Study Report Contents" Article in Section 26 0572 "Overcurrent Protective Device Short-Circuit Study."

F. Protective Device Coordination Study Report Contents: As specified in "Protective Device Coordination Study Report Contents" Article in Section 26 0573 "Overcurrent Protective Device Coordination Study."

G. Arc-Flash Study Output:

1. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

a. Voltage.

b. Calculated symmetrical fault-current magnitude and angle.
c. Fault-point X/R ratio.
d. No AC Decrement (NACD) ratio.
e. Equivalent impedance.
f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

H. Incident Energy and Flash Protection Boundary Calculations:

1. Arcing fault magnitude.
2. Protective device clearing time.
3. Duration of arc.
4. Arc-flash boundary.
5. Working distance.
6. Incident energy.
7. Hazard risk category.
8. Recommendations for arc-flash energy reduction.

I. Fault study input data, case descriptions, and fault-current calculations including a definition of terms and guide for interpretation of the computer printout.

2.3 ARC-FLASH WARNING LABELS

A. Comply with requirements in Section 26 0553 "Identification for Electrical Systems" for self-adhesive equipment labels. Produce a 3.5-by-5-inch self-adhesive equipment label for each work location included in the analysis.

B. The label shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include the following information taken directly from the arc-flash hazard analysis:

1. Location designation.
2. Nominal voltage.
3. Flash protection boundary.
4. Hazard risk category.
5. Incident energy.
6. Working distance.
7. Engineering report number, revision number, and issue date.

C. Labels shall be machine printed, with no field-applied markings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine Project overcurrent protective device submittals. Proceed with arc-flash study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to arc-flash study may not be used in study.

3.2 ARC-FLASH HAZARD ANALYSIS

A. Comply with NFPA 70E and its Annex D for hazard analysis study.

B. Preparatory Studies:

1. Short-Circuit Study Output: As specified in "Short-Circuit Study Output" Paragraph in "Short-Circuit Study Report Contents" Article in Section 26 0572 "Overcurrent Protective Device Short-Circuit Study."
2. Protective Device Coordination Study Report Contents: As specified in "Protective Device Coordination Study Report Contents" Article in Section 26 0573 "Overcurrent Protective Device Coordination Study."

C. Calculate maximum and minimum contributions of fault-current size.

1. The minimum calculation shall assume that the utility contribution is at a minimum and shall assume no motor load.
2. The maximum calculation shall assume a maximum contribution from the utility and shall assume motors to be operating under full-load conditions.

D. Calculate the arc-flash protection boundary and incident energy at locations in the electrical distribution system where personnel could perform work on energized parts.

E. Include medium- and low-voltage equipment locations, except equipment rated 240-V ac or less fed from transformers less than 125 kVA.

F. Safe working distances shall be specified for calculated fault locations based on the calculated arc-flash boundary, considering incident energy of 1.2 cal/sq.cm.

G. Incident energy calculations shall consider the accumulation of energy over time when performing arc-flash calculations on buses with multiple sources. Iterative calculations shall take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors and generators shall be decremented as follows:

1. Fault contribution from induction motors should not be considered beyond three to five cycles.
2. Fault contribution from synchronous motors and generators should be decayed to match the actual decrement of each as closely as possible (e.g., contributions from permanent magnet generators will typically decay from 10 per unit to three per unit after 10 cycles).

H. Arc-flash computation shall include both line and load side of a circuit breaker as follows:

1. When the circuit breaker is in a separate enclosure.
2. When the line terminals of the circuit breaker are separate from the work location.

I. Base arc-flash calculations on actual overcurrent protective device clearing time. Cap maximum clearing time at two seconds based on IEEE 1584, Section B.1.2.

3.3 POWER SYSTEM DATA

A. Obtain all data necessary for the conduct of the arc-flash hazard analysis.

1. Verify completeness of data supplied on the one-line diagram on Drawings "Arc-Flash Hazard Analysis" Article. Call discrepancies to the attention of Architect.
2. For new equipment, use characteristics submitted under the provisions of action submittals and information submittals for this Project.
3. For existing equipment, whether or not relocated, obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers.

B. Electrical Survey Data: Gather and tabulate the following input data to support study. Comply with recommendations in IEEE 1584 and NFPA 70E as to the amount of detail that is required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.

1. Product Data for overcurrent protective devices specified in other Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Obtain electrical power utility impedance at the service.
3. Power sources and ties.
4. Short-circuit current at each system bus, three phase and line-to-ground.
5. Full-load current of all loads.
6. Voltage level at each bus.
7. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in per cent, and phase shift.
8. For reactors, provide manufacturer and model designation, voltage rating and impedance.
9. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
10. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
11. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.
12. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
13. Motor horsepower and NEMA MG 1 code letter designation.

14. Low-voltage cable sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).
15. Medium-voltage cable sizes, lengths, conductor material, and cable construction and metallic shield performance parameters.

3.4 LABELING

A. Apply one arc-flash label for 600-V ac, 480-V ac, and applicable 208-V ac panelboards and disconnects and for each of the following locations:

1. Motor-control center.
2. Low-voltage switchboard.
3. Switchgear.
4. Medium-voltage switch.
5. Control panel.

3.5 APPLICATION OF WARNING LABELS

A. Install the arc-fault warning labels under the direct supervision and control of the Arc-Flash Study Specialist.

3.6 DEMONSTRATION

A. Engage the Arc-Flash Study Specialist to train Owner's maintenance personnel in the potential arc-flash hazards associated with working on energized equipment and the significance of the arc-flash warning labels.

END OF SECTION26 0574

SECTION 26 0800 - ELECTRICAL FACILITY STARTUP/COMMISSIONING

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope of Work

1. The Contractor is responsible to provide support required for start-up, testing, and commissioning. The commissioning process requires significant participation of Division 26 to ensure all portions of the work have been completed in a satisfactory and fully operational manner.

B. Minimum requirements for Contractor:

1. Start-up and testing of the equipment supplied.
2. Operate and maintain equipment and systems as required for commissioning tests.
3. Providing qualified personnel including equipment manufacturer's service technicians for participation with the commissioning team.
4. Provide equipment, materials, and labor necessary to correct deficiencies found during the commissioning process, which fulfill contract and warranty requirements.
5. Provide operation and maintenance information and record drawings for verification, organization, and distribution.
6. Provide assistance to the Commissioning Authority (CA) to develop and edit equipment startup and testing schedules (Commissioning Matrix).
7. Provide training for the systems specified in this division with coordination by the Contract Administrator and Commissioning Authority.
8. Attend commissioning meetings.

1.2 RELATED WORK

A. All start-up and testing procedures and documentation requirements specified within Division 26.

B. Allow sufficient time before final commissioning dates so that testing, adjusting and demonstration can be accomplished.

C. Put all electrical gear into full operation only after all testing has been completed, and the Commissioning Authority has received the testing documentation.

D. Provide labor and material to make corrections when required.

1.3 DEFINITIONS

A. Point Verification Forms (PVF) are detailed installation and startup tracking documents developed by the Commissioning Authority and completed through a cooperative effort between the Contractor and the Commissioning Authority. The PVFs will track each point through installation, termination, and connection to the Facility Management System (FMS).

B. Functional Performance Tests (FPT) are detailed testing procedure developed by the Commissioning Authority, and conducted through a cooperative effort between the Contractor and the Commissioning Authority. The FPTs will be detailed step by step procedures developed for each electrical system. The majority of electrical testing will be by the third party electrical testing firm. Commissioning Authority generated FPT's will be for systems such as lighting controls, dimmer controls, etc. Each FPT will have a clear acceptance criteria based in the contract documents which must be achieved before the system or sub-system is accepted by the Commissioning Authority and the Owner.

C. The Commissioning Authority (CA) is a firm hired directly by the Owner to oversee the entire commissioning process.

PART 2 - PRODUCTS

Not Applicable.

PART 3 - EXECUTION

3.1 WORK PRIOR TO COMMISSIONING

A. Complete all phases of work so the system can be tested, adjusted, and energized. Division 26 has primary start-up responsibilities with obligations to complete systems, including all sub-systems so they are fully functional and ready for testing and startup. This includes the complete installation of all equipment, materials, conduit, wire, supports, controls, etc., per the contract documents and related directives, clarifications, change orders, etc.

B. A commissioning plan will be developed by the CA and approved by the commissioning team. Division 26 is obligated to assist the CA in preparing the commissioning plan by providing all necessary information pertaining to the actual equipment and installation. If system modifications/clarifications are in the contractual requirements of this and related sections of work, they will be made at no additional cost to the Owner. If Contractor initiated system changes have been made that alter the commissioning process, notify the Commissioning Authority and Contract Administrator for approval.

C. Specific pre-commissioning responsibilities of Division 26 are as follows:

1. Bring each system to a fully construction completed state.

2. Commissioning is intended to begin upon completion of a system. To support Partial Occupancy commissioning may proceed prior to the completion of systems, or sub-systems, and will be coordinated with the CA as equipment Early Run. Start of commissioning before system completion will not relieve Division 26 from completing those systems as per the schedule.

3.2 PARTICIPATION IN COMMISSIONING

A. Provide skilled technicians to start up all systems within Division 26. These same technicians shall be made available to assist the CA in completing the commissioning program as it relates to each system and their technical specialty. Work schedules, time required for testing, etc., will be requested, coordinated by the CA, and tracked on the Commissioning Matrix. Division 26 will ensure that the qualified technician(s) are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustment, and/or problem resolutions.

B. System problems and discrepancies may require additional technician time or reconstruction of systems and system components. The additional technician time shall be made available for the subsequent commissioning periods until the required system performance is obtained.

C. The Contract Administrator and CA reserve the right to judge the appropriateness and qualifications of the technicians relative to each item of equipment or system. Qualifications of technicians include expert knowledge relative to the specific equipment involved, adequate documentation and tools to service/commission the equipment, and an attitude/willingness to work with the commissioning team to complete the job.

3.3 WORK TO RESOLVE DEFICIENCIES

A. In some systems, misadjustment, misapplied equipment and/or deficient performance under varying loads will result in additional work being required to commission the systems. This work will be completed under the direction of the Contract Administrator, with input from the Contractor, equipment supplier, and CA. Whereas all members will have input and the opportunity to discuss the work and resolve problems, the Contract Administrator will have final jurisdiction on the necessary work to be done to achieve performance.

B. Corrective work shall be completed in a timely fashion to permit completion of the commissioning process according to the schedule. Experimentation to render system performance will be permitted. If the CA deems the experimentation work to be ineffective or untimely as it relates to the commissioning process, the CA will notify the Owner indicating the nature of the problem, expected steps to be taken, and the deadline for completion of activities. If deadlines pass without resolution of the problem, the Owner reserves the right to obtain supplementary services and/or equipment to resolve the problem. Costs incurred to solve the problems in an expeditious manner will be the Contractor's responsibility.

3.4 TRAINING

A. Participate in the training of the Owner's engineering and maintenance staff, as required in Divisions 26, on each system and related components. Training, in part, will be conducted in a

classroom setting, with system and component documentation, and suitable classroom training aids.

B. Training will be conducted by the Contractor and the equipment vendors.

C. Training for the Commissioning Team members on the Commissioning Plan will be provided by the CA. All Commissioning Team members are required to attend this training.

3.5 SYSTEMS DOCUMENTATION

A. In addition to the requirements of Division 26, update contract documents to incorporate field changes and revisions to system designs to account for actual constructed configurations. Red-line all drawings on two sets. Include architectural floor plans, elevations and details, and the individual electrical systems in relation to actual building layout in Division 26 as-built drawings.

B. Maintain as-built red-lines as required by Division 1. Given the size and complexity of this project, red-line drawings at completion of construction, based on memory of key personnel, is not satisfactory. Continuous and regular red-lining of drawings is considered essential and mandatory. Maintain these drawings in the construction trailer and make them available for inspection at any time.

3.6 MISCELLANEOUS SUPPORT

A. Division 26 shall remove and replace covers of equipment, open access panels, etc., to permit Contractor, Contract Administrator, or CA to observe equipment and controllers provided.

END OF SECTION 26 0800

SECTION 26 0880 - ELECTRICAL ACCEPTANCE TESTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplemental General Conditions and Division 1 Specification Sections, apply to this Section.

B. Refer to individual specification sections indicated below for tests to be performed and other requirements.

1.2 QUALITY ASSURANCE

A. The Contractor will be responsible for all Electrical Testing and perform the independent inspections, tests, adjustments and settings as specified herein and in other sections.

B. The Electrical Testing will meet the requirements of NETA.

C. The Contractor shall submit appropriate documentation to demonstrate that it satisfactorily complies with the National Electrical Testing Association.

1. The Electrical Testing shall be regularly engaged in the testing of electrical equipment devices, installations, and systems.

D. The Electrical Testing shall utilize technicians who are regularly employed for testing services.

E. Technicians performing these electrical tests and inspections shall be trained and experienced concerning the apparatus and systems being evaluated. These individuals shall be capable of conducting the tests in a safe manner and with complete knowledge of the hazards involved. They must evaluate the test data and make an informed judgment on the continued serviceability or nonserviceability of the specific equipment. Technicians shall be certified in accordance with ANSI/NETA ETT–2000, Standard for Certification of Electrical Testing Technicians. Each on-site crew leader shall hold a current certification, Level III or higher, in electrical testing.

1.3 PERFORMANCE CRITERIA

A. Perform acceptance testing, inspection, and calibration to assure that installed electrical systems and equipment, either Owner or Subcontractor supplied are:

1. Installed in accordance with design Specifications and manufacturer’s instructions,
2. Ready to be energized,
3. Operational and within industry and manufacturer’s tolerances.

B. Refer to each division 26 specification sections for equipment and systems to be inspected, tested and calibrated by the Electrical Testing Agency.

1.4 REGULATORY REQUIREMENTS

A. Make Inspections and tests in accordance with the applicable codes and standards of the following agencies except as provided otherwise herein:

1. InterNational Electrical Testing Association – NETA ATS latest Edition: Acceptance Testing Specifications.
2. ANSI/NETA ETT – 2000, Standard for the Certification of Electrical Testing Technicians
3. National Fire Protection Association – NFPA.

    a. ANSI/NFPA 70: National Electrical Code.
    b. ANSI/NFP A 70B: Recommended Practice for Electrical Equipment Maintenance.
    c. NFPA 70E: Electrical Safety Requirements for Employee Workplaces.
    d. NFPA 99 & 101.

B. Use the following references:

1. Project design Specifications.
2. Project ELECTRICAL SYSTEM PROTECTIVE DEVICE STUDY – refer to Sections 26 0572, 26 0573, and 26 0574.
3. Manufacturer's instruction manuals applicable to each particular apparatus.
4. Project list of equipment to be inspected and tested.

1.5 GENERAL REQUIREMENTS

A. Safety and Precautions

This document does not include any procedures, including specific safety procedures. It is recognized that an overwhelming majority of the tests and inspections recommended in these specifications are potentially hazardous. Inherent in this determination is the prerequisite that individuals performing these tests be capable of conducting the tests in a safe manner and with complete knowledge of the hazards involved.

1. Safety practices shall include, but are not limited to, the following requirements:

    a. Occupational Safety and Health Act.
    b. Accident Prevention Manual for Industrial Operations, National Safety Council.
    c. Applicable state and local safety operating procedures.
    d. Owner's safety practices.
    e. ANSI/NFPA 70E, Electrical Safety Requirements for Employee Workplaces.

2. All tests shall be performed with apparatus de-energized except where otherwise specifically required.
3. The Electrical Testing Agency shall have a designated safety representative on the project to supervise operations with respect to safety.

B. Suitability of Test Equipment

1. All test equipment shall be in good mechanical and electrical condition.
2. Split-core current transformers and clamp-on or tong-type ammeters require consideration of the following in regard to accuracy:

    a. Position of the conductor within the core
    b. Clean, tight fit of the core pole faces
    c. Presence of external magnetic fields
    d. Accuracy of the current transformer ratio in addition to the accuracy of the secondary meter.

3. Selection of metering equipment shall be based on knowledge of the waveform of the variable being measured. Digital multimeters may be average or RMS sensing and may include or exclude the dc component. When the variable contains harmonics or dc offset and, in general, any deviation from a pure sine wave, average sensing, RMS scaled meters may be misleading.
4. Field test metering used to check power system meter calibration must have accuracy higher than that of the instrument being checked.
5. Accuracy of metering in test equipment shall be appropriate for the test being performed but not in excess of two percent of the scale used.
6. Waveshape and frequency of test equipment output waveforms shall be appropriate for the test and tested equipment.

C. Test Instrument Calibration

1. The Electrical Testing Agency shall have a calibration program which assures that all applicable test instruments are maintained within rated accuracy.
2. The accuracy shall be directly traceable to the National Institute of Standards and Technology (NIST).
3. Instruments shall be calibrated in accordance with the following frequency schedule:

    a. Field instruments: Analog, 6 months maximum; Digital, 12 months maximum
    b. Laboratory instruments: 12 months
    c. Leased specialty equipment: 12 months where accuracy is guaranteed by lessor.

4. Dated calibration labels shall be visible on all test equipment.
5. Records, which show date and results of instruments calibrated or tested, shall be kept up-to-date.
6. Up-to-date instrument calibration instructions and procedures shall be maintained for each test instrument.
7. Calibrating standard shall be of higher accuracy than that of the instrument tested.

D. Test Report

1. The test report shall include the following:

    a. Summary of project.
    b. Description of equipment tested.
    c. Description of test.

d. Test data.
e. Analysis and recommendations.

2. Test data records shall include the following minimum requirements:

a. Identification of the testing organization.
b. Equipment identification.
c. Humidity, temperature, and other atmospheric conditions that may affect the results of the tests/calibrations.
d. Date of inspections, tests, maintenance, and/or calibrations.
e. Identification of the testing technician.
f. Indication of inspections, tests, maintenance, and/or calibrations to be performed and recorded.
g. Indication of expected results when calibrations are to be performed.
h. Indication of “as-found” and “as-left” results.
i. Sufficient spaces to allow all results and comments to be indicated.

3. The Electrical Testing Agency shall furnish a copy or copies of the complete report to the owner and Commissioning Authority as required in the acceptance contract.

1.6 SUBMITTALS

A. Qualifications of the Electrical Testing Agency shall be submitted to the COMMISSIONING AUTHORITY for review with the electrical equipment submittals in accordance with Section 26 0500, "COMMON WORK RESULTS FOR ELECTRICAL, Submittals."

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

3.1 GENERAL

A. Set all adjustable circuit breaker trip settings in accordance with the trip setting report from the ELECTRICAL SYSTEM PROTECTIVE DEVICE STUDY.

B. Test, inspect and calibrate the following electrical equipment in strict accordance with applicable sections of NETA ATS-2003.

1. Electrical equipment shown on the electrical Drawings.
2. Electrical equipment specified in all Division 26 Specifications for the Site.
3. Electrical equipment furnished under other Divisions of the Specifications and connected under Division 26.

C. Perform acceptance tests and inspections prior to energizing equipment, unless where energization is required to perform specified tests.

D. Final acceptance will not occur before completion of the electrical acceptance tests, inspections and calibrations specified in this Section.

3.2 FIELD QUALITY CONTROL

A. Standards: Comply with applicable standards of the InterNational Electrical Testing Association (NETA), including standard ATS.

B. Acceptance Testing: After installing equipment and BEFORE electrical circuitry has been energized. Demonstrate product capability and compliance with requirements.

3.3 DIVISION OF RESPONSIBILITY

A. The Electrical Testing Agency shall provide all material, equipment, labor and technical supervision to perform such tests and inspections as specified herein.

B. The Electrical Testing Agency is responsible for programming all protective and alarming devices with the proper settings provided by the ELECTRICAL SYSTEM PROTECTIVE DEVICE STUDY. Settings shall not be changed or applied to any device without written authorization from the Owner.

C. The Electrical Testing Agency shall notify the Contractor and Owner immediately upon the discovery of any defective equipment or incorrect system design or installation.

D. The Electrical Testing Agency shall provide an experienced person on-site during energizing, with appropriate test equipment to provide assistance in the event of a malfunction during the system start-up process.

3.4 ACCEPTANCE TESTING PROCEDURES

A. Testing and acceptance procedures for the equipment and systems listed in Part 1 shall be as described in the individual equipment specification sections listed above.

END OF SECTION 26 0880

SECTION 26 0913 - LIGHTING CONTROL EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following types of lighting controls:

1. Time switches.

2. Lighting contactors.

B. Related Sections: The following Sections contain requirements that relate to this Section:

1. Division 26, Section 26 0533, Raceway and Boxes for Electrical Systems, for general component identification and support requirements.

2. Division 26, Section 26 0553, Identification for Electrical Systems, and general identification requirements.

3. Division 26, Section 26 0800, Electrical Facility Startup / Commissioning, for turn-key startup of all programmable, networked, and/or software-based lighting control system(s).

1.3 SUBMITTALS

A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.

B. Product Data for lighting control equipment and systems components, including dimensions and data on features and components. Include wiring diagrams and elevation views of front panels of control and indicating devices. Include data on ratings. For flush control panels, submit color and finish options for selection. Also include the following:

1. Lists of ballast and lamp combinations compatible with dimmer systems, by manufacturer and catalog number.
2. Sound data, including operational tests of dimming systems.
3. Operational documentation for software.

C. Shop Drawings detailing assemblies of standard components, custom assembled for specific application on Project. Indicate dimensions, weights, arrangement of components, and clearance and access requirements.

D. Wiring diagrams detailing specific systems tailored to this Project and differentiating between factory-installed and field-installed wiring.

E. Field test reports indicating and interpreting test results specified in Part 3 of this Section.

F. Maintenance data for lighting control equipment and systems components to include in the operation and maintenance manual specified in Division 1.

G. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices to be used. Describe characteristics of network and other data communication lines.

H. Coordination Drawings: Submit evidence that lighting controls are compatible with connected monitoring and control devices and systems specified in other Sections.

1. Show interconnecting signal and control wiring and interfacing devices that prove compatibility of inputs and outputs.
2. For networked controls, list network protocols and provide statements from manufacturers that input and output devices meet interoperability requirements of the network protocol.

I. Software licenses and upgrades required by and installed for operation and programming of central lighting control panels “LCP’s”. Install software on the same personal computer “PC” workstation(s) as used for the monitoring and control as the Division 23 Facility Management System “FMS” / Energy Management System “EMS” / Building Automation System “BAS”.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For lighting controls to include in emergency, operation, and maintenance manuals.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On a magnetic media or compact disc, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

1.5 QUALITY ASSURANCE

A. Electrical Component Standard: Provide components that comply with NFPA 70 and that are listed and labeled by UL where available.

B. Comply with FCC Regulations of Part 15, Subpart J for Class A.

C. Listing and Labeling: Provide products specified in this Section that are listed and labeled.

1. The Terms "Listed" and "Labeled": As defined in the National Electrical Code, Article 100.
2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.

1.6 WARRANTY

A. General Warranty: The special warranty specified in this Article shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by the Contractor under requirements of the Contract Documents.

B. Special Warranty: Submit a written warranty signed by manufacturer and Installer agreeing to replace programmable lighting control system components that fail in materials or workmanship within the specified warranty period.

C. Warranty Period: 2 years from date of Substantial Completion.

1.7 EXTRA MATERIALS

A. Furnish extra products as described below that match products installed, are packaged with protective covering for storage, and are identified with labels describing contents. Deliver extra materials to Owner.

1. Relays: Single-pole mechanically held, 1 for every 4 installed. Furnish at least one of each type.
2. Dimmer Modules: 1 for every 4 of each type and rating installed. Furnish at least one of each type.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, provide one of the products specified in on the drawings. Where no manufacturer is listed for the appropriate product category, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:

1. Contactors and Relays:

a. Square D Co.
b. Eaton Corporation
c. Siemens

2. Time Switches:

a. NSi Industries / Tork, Inc.
b. Intermatic, Inc.

2.2 CONTACTORS AND RELAYS

A. Comply with NEMA ICS 2.

B. Description: Devices are electrically operated and mechanically held. Number of poles and ratings are as indicated. Coordinate rating of each unit with type of load served, including tungsten filament and inductive-type loads.

C. Modular Single-Pole Relays: Split-coil, momentary-pulsed type, knockout mounting.

1. Low-Voltage Leads: 5-pin plug connector.
2. Pilot Contacts: Single pole.
3. Rated Capacity: 20 A, 125 VAC for tungsten filaments, and 20 A, 277 VAC for ballasts.
4. Endurance: 50,000 cycles at rated capacity.

D. Modular Relay Panels: Steel cabinets, preassembled with modular single-pole relays, transformer power supplies, and associated components.

1. Barriers separate low-voltage and line-voltage components.
2. Cover: Hinged, lockable type.
3. Directory: Mounted on back of door. Identifies relays and loads controlled.

2.3 TIME SWITCHES

A. Time Switches: Solid-state programmable units with alphanumeric display conforming to UL 917. Include the following features:

B. Time Switches: Electromechanical-dial type conforming to UL 917. Include the following features:

1. Astronomic dial.
2. Contacts: 2, rated 30 A at 277 VAC, except as otherwise indicated.
3. Pilot-Duty Contacts: 2, rated 2 A at 240 V, except as otherwise indicated.
4. Eight-Day Program: Uniquely programmable for each day of the week and holidays.
5. Skip-day mode.

2.4 MANUAL SWITCHES AND PLATES

A. Switches: Specification grade, modular, momentary push-button, low-voltage type.

1. Color: White, except as otherwise indicated.
2. Integral Pilot Light: Indicates when circuit is on. Use where indicated.
3. Locator Light: Internal illumination helps locate switch in the dark. Use where indicated.
4. Wall Plates: Match those specified in Division 26, Section 26 2726, Wiring Devices to materials, finish, and color. Use multigang plates where more than one switch is indicated at a location.
5. Legend: Engraved or permanently silk-screened on wall plate where indicated. Use designations indicated on Drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install equipment according to manufacturers' written instructions.

B. Mount control equipment according to manufacturers' instructions and Division 26, Section 26 2726, Wiring Devices.

C. Mounting heights indicated are to bottom of unit for suspended items and to center of unit for wall-mounted ones.

3.2 CONTROL WIRING INSTALLATION

A. Install wiring between control devices as specified in Division 26 Section 26 2726, Wiring Devices.

B. Wiring Method: Install all wiring in raceway as specified in Division 26, Section 26 0533, Raceway and Boxes for Electrical Systems.

C. Wiring Method: Install all wiring in raceway as specified in Division 26, Section 26 0533, Raceways and Boxes for Electrical Systems, except where run in accessible ceiling space, and gypsum board partitions.

D. Bundle, train, and support wiring in enclosures.

E. Grounding: Ground equipment. Tighten electrical connectors and terminals, including grounding connections, according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.3 IDENTIFICATION

A. Identify components and power and control wiring according to Division 26, Section 26 0553, for Identification for Electrical Systems.

B. Label each system control module with a unique designation. Make designations on elevated components readable from floor.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Services: Provide services of a factory-authorized service representative to test, adjust, and program lighting control systems.

B. Reports: Prepare written reports of tests and observations. Report defective materials and workmanship and unsatisfactory test results. Record repairs and adjustments.

C. Test Labeling: After satisfactory completion of tests and inspections, apply a label to tested components indicating test results, date, and responsible organization and person.

D. Schedule visual and mechanical inspections and electrical tests with at least 7 days' advance notice.

E. Visual and Operational Inspections: Include the following inspections.

1. Inspect control components for defects and physical damage, NRTL labeling, and nameplate compliance with current Project Drawings.
2. Check tightness of electrical connections with torque wrench calibrated within previous 6 months. Use manufacturers recommended torque values.
3. Verify settings of photoelectric devices with photometer calibrated to National Institute for Science and Technology (NIST) standards within past 6 months.
4. Exercise and perform operational tests on mechanical parts and operable devices according to manufacturer's instructions for routine functional operation.

F. Electrical Tests: Use particular caution when testing devices containing solid-state components. Perform the following tests according to manufacturer's instructions:

1. Continuity tests of circuits.
2. Operational Tests: Set and operate controls to demonstrate controls in a methodical sequence that cues and reproduces actual operating functions. Include testing of dimming equipment and ambient-light, programmable, and occupancy controls under conditions that simulate actual operational conditions. Record control settings, operations, cues, and functional observations.

G. Correct deficiencies disclosed by inspections and tests, make necessary adjustments, and retest deficient items. Verify that specified requirements are met.

3.5 ADJUSTING AND CLEANING

A. Occupancy Adjustments: Upon request within 1 year of date of Substantial Completion, make up to 3 on-site visits to Project site to assist in adjusting light levels, making program changes, and adjusting sensors and controls.

B. Repair scratches and mars of finish to match original finish. Clean equipment and devices internally and externally using methods and materials recommended by manufacturers.

3.6 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Confirm correct communication wiring, initiate communications between panels, and program the lighting control system according to approved zone configuration schedules, time-of-day schedules, and input override assignments.

3.7 DEMONSTRATION

A. Training: Provide services of a factory-authorized service representative to demonstrate programmable lighting control system and to train Owner's maintenance personnel.

1. Train Owner's personnel to operate, service, maintain, adjust, and program equipment and system components. Allow at least 4 hours to conduct training. Schedule training with at least 7 days' advance notice. Use final approved operation and maintenance manual as a training aid throughout training. Use both classroom training and hands-on exercises.

END OF SECTION 26 0913

SECTION 26 0923 - DIGITAL OCCUPANCY AND DAYLIGHT MANAGEMENT CONTROL SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Digital Occupancy and Daylighting Sensor Control
2. Emergency Lighting Control (if applicable)

B. Related Section

1. Section 26 0913 – Lighting Control Equipment.
2. Section 26 2416 – Panelboards.
3. Section 26 2726 – Wiring Devices.
4. Section 26 5119 – LED Interior Lighting.
5. Section 26 0500 – Common Work Results

C. Control Intent – Control Intent includes, but is not limited to:

1. Defaults and initial calibration settings for such items as time delay, sensitivity, fade rates, etc.
2. Initial sensor and switching zones
3. Initial time switch settings
4. Task lighting and receptacle controls
5. Emergency Lighting control (if applicable)

1.2 REFERENCES

A. American National Standards Institute/Institute of Electrical and Electronic Engineers (ANSI/IEEE)

B. Canadian Standards Association (CSA) (www.csa.ca).

C. International Electrotechnical Commission (www.iec.ch)

D. International Organization for Standardization (ISO)

E. National Electrical Manufacturers Association (NEMA) (www.nema.org)

F. WD1 (R2005) - General Color Requirements for Wiring Devices.

G. Underwriters Laboratories, Inc. (UL) (www.ul.com):

1. 916 – Energy Management Equipment.
2. 924 – Emergency Lighting

H. International Building (IBC) Current Issue

1.3 SYSTEM DESCRIPTION & OPERATION

A. The Lighting Control and Automation system as defined under this section covers the following equipment:

1. Digital Room Controllers – Self configuring, digitally addressable one, two or three relays controllers with 0-10v control for ballasts (if applicable) and single relay application specific plug load controllers.
2. Digital Occupancy Sensors – Self configuring, digitally addressable and calibrated occupancy sensors with LCD screens and two way active Infra-Red (IR) configurations.
3. Digital Switches – Self configuring, digitally addressable push button switches, dimmers, and scene switches with two way active Infra-Red (IR) communications.
4. Analog and digital closed loop daylighting sensors - self-calibrating daylighting sensors that provide closed loop control to Room Controllers. Sensors and Room Controllers can provide single or multi-zone, on/off or dimming control for daylight harvesting.
5. Hand held remotes for room configuration – provides two way infrared communications to digital devices and allows complete configuration and reconfiguration of the device / room from 30 feet away. Unit to have Organic LED display, simple pushbutton interface, and allow send / receive / store of all room variables.
6. Hand held remotes for personal control – One, two, or four (scene) button remotes provide Infrared communications to a room. Remote controls will support ON/OFF, scene control and may be configured in the field to provide specific occupant requirements without special tools.
7. Digital Lighting Management (DLM) local network – Free topology, plug in wiring system (Cat 5e) for power and data to room devices.
8. Native BACnet Module (if applicable) – Provide MS/TP communications for Room to Room, or Room to Server communications.
9. Emergency Lighting Control Unit (ELCU)- allows any standard lighting control device to control emergency lighting in conjunction with normal lighting in any area within a building

1.4 LIGHTING CONTROL APPLICATIONS

A. Unless relevant provisions of the applicable local Energy Codes are more stringent, provide a minimum application of lighting controls as follows:

1. Space Control Requirements – Provide occupancy/vacancy sensors with manual-on functionality in all spaces except toilet rooms, storerooms, library stacks, or other applications where hands-free operation is desirable and automatic-on occupancy sensors are more appropriate. Provide manual ON occupancy/vacancy sensors for any enclosed office, conference room, meeting room, open plan system and training room. For spaces with multiple occupants or where line-of-sight may be obscured, provide ceiling- or corner-mounted sensors with manual-on switches.
2. Bi-Level Lighting – Provide multi –level switched dimming controls in all spaces except toilet rooms, storerooms, library stacks, or applications where variable dimming is used.

3. Task Lighting / Plug Loads – Provide automatic shut off of non essential plug loads and task lighting in all spaces except toilet rooms and storerooms. Provide automatic ON of plug loads whenever spaces are occupied. For spaces with multiple occupants a single shut off consistent with the overhead lighting may be used for the area.
4. Daylighted Areas. All luminaries within 15’ of windows or within 7’ of skylights (the daylighted zone) shall be separately controlled from luminaires outside of daylighted zones. Luminaires closest to the daylight aperture shall be separately controlled from luminaires farther from the daylight aperture, within the daylight zone.
5. Daytime set points for total illumination (combined daylight and electric light) level that initiate dimming shall be programmed to be not less than 125% of the nighttime maintained designed illumination levels.
6. Multiple-leveled switched daylight harvesting controls may be utilized for areas marked on drawings.
7. Provide smooth and continuous daylight dimming for areas marked on drawings. Daylight system may be designed to turn off ambient lighting when daylight is at or above required lighting levels, only if system functions to turn lamps back on at dimmed level, rather than turning full-on prior to dimming.

B. Additional controls.

1. Provide occupancy/vacancy sensors for any enclosed office, conference room, meeting room, and training room. For spaces with multiple occupants or where line-of-sight may be obscured, provide ceiling- or corner-mounted with manual-on switches.
2. Conference, meeting, training, auditoriums, and multipurpose rooms shall have controls that allow for independent control of each local control zone. Rooms larger than 300 square feet shall instead have at least four (4) pre-set lighting scenes unless otherwise specified. Occupancy / vacancy sensors shall be provided to extinguish all lighting in the space.

1.5 SUBMITTALS

A. Submittals Package: Submit the shop drawings, and the product data specified below at the same time as a package.

B. Shop Drawings (For Sensor Systems):

1. Composite wiring and/or schematic diagram of each control circuit as proposed to be installed (standard diagrams will not be accepted).
2. Scale drawing for each area showing exact location of each sensor, switching module, and on-off-auto switch.

C. Product Data: Catalog sheets, specifications and installation instructions.

D. Include data for each device which:

1. Indicates where sensor is proposed to be installed.
2. Prove that the sensor is suitable for the proposed application.

1.6 QUALITY ASSURANCE

A. Manufacturer: Minimum 10 years experience in manufacture of lighting controls.

1.7 PROJECT CONDITIONS

A. Do not install equipment until following conditions can be maintained in spaces to receive equipment:

1. Ambient temperature: 0° to 40° C (32° to 104° F).
2. Relative humidity: Maximum 90 percent, non-condensing.

1.8 WARRANTY

A. Provide a five year complete manufacturer's warranty on all products to be free of manufacturers' defects.

1.9 MAINTENANCE

A. Spare Parts:

1. Provide 1 of each product to be used for maintenance.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturer:

1. Watt Stopper
   a. System: Digital Lighting Management (DLM)

B. Substitutions:

1. All proposed substitutions (clearly delineated as such) must be submitted in writing for approval by the design professional according to 01 6000 Product Requirements, Substitution Procedures. Proposed substitutes must be accompanied by a review of the specification noting compliance on a line-by-line basis.
2. By using pre-approved substitutions, the contractor accepts responsibility and associated costs for all required modifications to circuitry, devices, and wiring. The contractor shall provide complete engineered shop drawings (including power wiring) with deviations for the original design highlighted in an alternate color to the engineer for review and approval prior to rough-in.

2.2 SINGLE / DUAL RELAY WALL SWITCH VACANCY SENSORS

A. PIR: Manual ON, Automatic OFF Wall switch type passive infrared occupancy sensor with built-in override control (off-auto). Furnish the Company's model which suits the electrical system parameters, and accommodates the square footage coverage and wattage requirement for each area (and type of lighting) controlled.

B. Ultrasonic: Manual ON, Automatic OFF Wall switch type ultrasonic occupancy sensor with built-in override control (off-auto). Furnish the Company's model which suits the electrical system parameters, and accommodates the square footage coverage and wattage requirement for each area (and type of lighting) controlled.

C. Dual technology: Manual ON, Automatic OFF Wall switch type dual technology, passive Infrared and ultrasonic occupancy sensor with built-in override control (off-auto). Furnish the Company's model which suits the electrical system parameters, and accommodates the square footage coverage and wattage requirement for each area (and type of lighting) controlled.

2.3 DIGITAL WALL OR CEILING MOUNTED OCCUPANCY SENSOR SYSTEM

A. Wall or ceiling mounted (to suit installation) passive infrared, ultrasonic or dual technology digital (passive infrared and ultrasonic) occupancy sensor. Furnish the Company's system which accommodates the square footage coverage requirements for each area controlled, utilizing Room Controller modules and accessories which suits the lighting and electrical system parameters.

B. Digital Occupancy Sensors shall provide graphic LCD display for digital calibration and electronic documentation. Features include the following:

1. Digital calibration and LCD entry for the following variables:

    a. Sensitivity,
    b. Time Delay
    c. PIR, Ultrasonic or Dual Technology activation
    d. Re-strike times.
    e. Walk-through mode

2. Two RJ-45 digital connections for DLM local network.
3. Two-way infrared communications port to allow remote programming through hand held commissioning tool.
4. Self contained push buttons for programming and control of room devices.
5. Device Status LED's including:

    a. Network Status LED to indicate data transmission
    b. Power LED to indicate the device has power
    c. LED for each sensor technology to indicate detected motion.

C. Units will provide for digital calibration and commissioning and will not have any dip switches or potentiometers for field settings

D. Multiple occupancy sensors may be installed in a room by simply connecting them to the free topology DLM local network. No additional configuration will be required

2.4 DIGITAL WALL SWITCHES

A. Low voltage (RJ-45) momentary push button switches in 1,2,3,4 and 8 button configuration, decorator opening. Wall switches will include the following features:

1. Two way infrared communications port for use with personal and configuration remote controls.
2. LED's for status, programming, and troubleshooting including:

    a. One pilot LED for each button.
    b. One locator LED per switch.

3. Engraveable buttons
4. Dimming switches shall include seven LED's to indicate load levels.
5. Scene switches shall include pilot indication of scene selection.
6. Device Status LED's including:

    a. Network Status LED to indicate data transmission
    b. Power LED to indicate the device has power

B. Switches shall have two RJ-45 ports to allow connection to any other digital room device.

C. Multiple digital wall switches may be installed in a room by simply connecting them to the free topology DLM local network. No additional configuration will be required to achieve multi-way switching

2.5 ROOM CONTROLLERS

A. Room Controllers automatically bind the room loads to the connected devices in the space without any tools or configuration requirements. Room Controllers shall be provided to match the room lighting load and control requirements and sequences. The controllers will be simple to install and will not have screw type connections, dip switches, potentiometers or require special mounting or configuration. The control units will include the following features:

1. Automatic room configuration to the most energy efficient sequence of operation based upon the devices in the room.
2. One or two relay configuration
3. Simple replacement – Using the default automatic configuration capabilities, a room controller may be replaced with an Off-the-Shelf unit without requiring any configuration or setup.
4. Device Status LED's including:

    a. Network Status LED to indicate data transmission.
    b. Power LED to indicate the device has power.
    c. Load status.

5. Quick installation features including:

    a. Standard junction box mounting.
    b. Quick low voltage connections using standard RJ-45 patch cables.
    c. Manual override and pilot indication for each load.
    d. Universal voltage (120 – 277 VAC).
    e. Zero cross circuitry.
    f. Low power consumption, 150 ma switched power supply for sensors and switches.
    g. Three RJ-45 DLM local network ports.
    h. Enhanced Room Controllers shall include all the features of the Room Controller plus the following enhancements:
    i. One, two or three relay configuration.
    j. 250 ma switched power supply.
    k. Four RJ-45 DLM local network ports.
    l. One zero to 10 volt analog output per relay for control of dimmable ballasts.
    m. Optional BACnet MS/TP communications port.
    n. Current monitoring.
    o. Plug Load Room Controllers provide dedicated control of plug loads within the space. The controllers plug into the DLM local network using the RJ-45 free topology network. The room controllers include the following features.
    p. One relay configuration only.
    q. Automatic ON/OFF configuration based upon room occupancy.
    r. Default 30 minute (adjustable) additional time delay from lighting shut off to allow for electronic component use after an area is vacant.

2.6 DIGITAL PHOTOSENSORS

A. Provide automatic daylight harvesting capabilities to the Room Controllers. The photo sensor / room controller configuration automatically configures the daylighting set points for ON/OFF or Dimming control. Using the automatic configuration replacing a photo sensor or room controller can be done without any special tools, programming or configuration. Photosensors include the following features:

1. The digital photosensor shall utilize an internal photodiode that measures light in a 100 degree angle cutting the unwanted light from bright sources outside of this cone
2. The digital photosensor shall be capable of turning lighting on and off or Raise / Lower depending on the binding to the Room Controller. Sensor range shall be from 1 - 1400fc.
3. For ON/OFF daylight harvesting the controller provides a “hold on while occupied” feature that prohibits high levels from turning OFF the controlled lights as long as the space remains occupied.
4. The sensor has a threaded nipple that mounts on a ceiling tile and for more challenging applications such as a side wall or hard rock ceiling the nipple pops off and the unit can be screwed down.

2.7 ROOM NETWORK

A. The DLM local network is a free topology lighting control network and protocol designed to control a small area of a building. Digital room devices connect to the network using RJ-45

patch cords which provide both data and power to the sensors and switches. Features of the DLM local network include

1. Automatic configuration and binding of sensors, switches and lighting loads to the most energy efficient sequence of operation based upon the device attached.
2. Simple replacement of any device in the network with a standard off the shelf unit without requiring commissioning, configuration or setup.
3. Push and Learn configuration that can change the automatic binding process and load parameters by using only the digital devices in the room.
4. Two way infrared communications that allow load parameters, sensor configuration and binding operations to be configured through a hand held configuration tool up to 30 feet from any device

B. Support for the following devices within a room:

1. 64 loads within the room
2. 64 switches
3. 6 occupancy sensors
4. Maximum of 800 milliamps of power for sensors, switches and auxiliary devices.

2.8 EMERGENCY LIGHTING

A. Emergency Lighting Control Unit – A UL 924 listed device that monitors a switched circuit providing normal lighting to an area. The unit provides normal ON/OFF control of emergency lighting along with the normal lighting. Upon normal power failure the emergency lighting circuit will close, forcing the emergency lighting ON until normal power is restored. Features include

1. 120 - 277 volts, 50/60 Hz, 20 amp ballast rating
2. Push to test button
3. Auxiliary contract for test / Fire Alarm system

PART 3 - EXECUTION

3.1 INSTALLATION

A. When using wire other than RJ-45 connections provide detailed point to point wiring diagrams for every termination. Provide wire specifications and wire colors to simplify contactor termination requirements

B. Install the work of this Section in accordance with manufacturer's printed instructions unless otherwise indicated.

C. Calibrate all sensor time delays and sensitivity to guarantee proper coverage of occupants and energy savings.

1. Adjust time delay so that controlled area remains lighted for 5 minutes after occupant leaves area.

D. Provide written or computer generated documentation on the commissioning of the system including room by room description including:

1. Sensor parameters, time delays, sensitivities, daylighting set points.
2. Sequence of operation, manual ON, Auto OFF, etc.
3. Load Parameters - blink warning, etc.

E. Re-commissioning – After 30 days from occupancy re-calibrate all sensors time delays and sensitivities to meet the Owner's Project Requirements. Provide a detailed report to the Architect / Owner of re-commissioning activity.

F. Spare Parts – Provide to Owner ten (10) spare units of each device and cable used in this system.

END OF SECTION 26 0923

SECTION 26 2213 - LOW-VOLTAGE DISTRIBUTION TRANSFORMERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes distribution, dry-type transformers with a nominal primary and secondary rating of 600 V and less, with capacities up to 1500 kVA.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each type and size of transformer.
2. Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer.

B. Shop Drawings:

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.
3. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Seismic Qualification Data: Certificates, for transformers, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
4. Certification: Indicate that equipment meets Project seismic requirements.

C. Source quality-control reports.

D. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For transformers to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Testing Qualifications: Accredited by NETA.

1. Contractors Testing Field Supervisor: Certified by NETA to supervise on-site testing.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Inspection: On receipt, inspect for and note any shipping damage to packaging and transformer.

1. If manufacturer packaging is removed for inspection, and transformer will be stored after inspection, re-package transformer using original or new packaging materials that provide protection equivalent to manufacturer's packaging.

B. Storage: Store in a warm, dry, and temperature-stable location in original shipping packaging.

C. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

D. Handling: Follow manufacturer's instructions for lifting and transporting transformers.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Acme Electric Corporation.
2. Controlled Power Company; an Emerson company.
3. Dongan Electric Manufacturing Company.
4. Eaton.
5. Federal Pacific.
6. General Electric Company.
7. Hammond Power Solutions Inc.
8. Jefferson Electric, Inc.

9. Lincoln Electric Products Co., Inc.
10. Mag-Tran; a division of Quality Transformer & Electronics.
11. Marcus Transformer LTD.
12. MGM Transformer Company.
13. Micron Industries Corporation.
14. Mirus International Inc.
15. Square D

B. Source Limitations: Obtain each transformer type from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Transformers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the transformer will remain in place without separation of any parts when subjected to the seismic forces specified and the transformer will be fully operational after the seismic event."

2.3 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.

B. Comply with NFPA 70.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

C. Transformers Rated 15 kVA and Larger:

1. Comply with 10 CFR 431 (DOE 2016) efficiency levels.
2. Marked as compliant with DOE 2016 efficiency levels by an NRTL.

D. Shipping Restraints: Paint or otherwise color-code bolts, wedges, blocks, and other restraints that are to be removed after installation and before energizing. Use fluorescent colors that are easily identifiable inside the transformer enclosure.

2.4 DISTRIBUTION TRANSFORMERS

A. Comply with NFPA 70, and list and label as complying with UL 1561.

B. Provide transformers that are constructed to withstand seismic forces per project seismic requirements.

C. Cores: Electrical grade, non-aging silicon steel with high permeability and low hysteresis losses.

1. One leg per phase.
2. Core volume shall allow efficient transformer operation at 10 percent above the nominal tap voltage.

3. Grounded to enclosure.

D. Coils: Continuous windings without splices except for taps.

1. Coil Material: Copper.
2. Internal Coil Connections: Brazed or pressure type.
3. Terminal Connections: Bolted.

E. Encapsulation: Transformers smaller than 30 kVA shall have core and coils completely resin encapsulated.

F. Enclosure: Ventilated.

1. NEMA 250, Type 2: Core and coil shall be encapsulated within resin compound using a vacuum-pressure impregnation process to seal out moisture and air.
2. KVA Ratings: Based on convection cooling only and not relying on auxiliary fans.
3. Wiring Compartment: Sized for conduit entry and wiring installation.
4. Finish: Comply with NEMA 250.

a. Finish Color: ANSI 49 gray weather-resistant enamel.

G. Enclosure: Ventilated.

1. NEMA 250, Type 3R: Core and coil shall be encapsulated within resin compound, sealing out moisture and air.
2. Wiring Compartment: Sized for conduit entry and wiring installation.
3. Finish: Comply with NEMA 250.

a. Finish Color: ANSI 49 gray weather-resistant enamel.

H. Taps for Transformers 3 kVA and Smaller: One 5 percent tap above normal full capacity.

I. Taps for Transformers 7.5 to 24 kVA: One 5 percent tap above and one 5 percent tap below normal full capacity.

J. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and four 2.5 percent taps below normal full capacity. See "Insulation Ratings" Article in the Evaluations for discussion of insulation classes. See "Energy Considerations" Article in the Evaluations for discussion of relative efficiencies. Temperature rise of 115 or 80 deg C only applies to transformers 15 kVA and larger.

K. Insulation Class, Smaller Then 30 kVA: 180 deg C, UL-component-recognized insulation system with a maximum of 115 deg C rise above 40 deg C ambient temperature.

L. Insulation Class, 30 kVA and Larger: 220 deg C, UL-component-recognized insulation system with a maximum of 115 deg C rise above 40 deg C ambient temperature.

M. Grounding: Provide ground-bar kit or a ground bar installed on the inside of the transformer enclosure.

N. K-Factor Rating: Transformers indicated to be K-factor rated shall comply with UL 1561 requirements for nonsinusoidal load current-handling capability to the degree defined by designated K-factor.

1. Unit shall not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor, without exceeding the indicated insulation class in a 40 deg C maximum ambient and a 24-hour average ambient of 30 deg C.
2. Indicate value of K-factor on transformer nameplate.
3. Unit shall comply with requirements of DOE 2016 efficiency levels when tested according to NEMA TP 2 with a K-factor equal to one.

O. Electrostatic Shielding: Each winding shall have an independent, single, full-width copper electrostatic shield arranged to minimize inter-winding capacitance.

1. Arrange coil leads and terminal strips to minimize capacitive coupling between input and output terminals.
2. Include special terminal for grounding the shield.

P. Neutral: Rated 200 percent of full load current for K-factor-rated transformers.

Q. Wall Brackets: Manufacturer's standard brackets.

R. Low-Sound-Level Requirements: Maximum sound levels when factory tested according to IEEE C57.12.91, as follows:

1. 9.00 kVA and Less: 40dBA.
2. 9.01 to 30.00 kVA: 45dBA.
3. 30.01 to 50.00 kVA: 45 dBA for K-factors of 4dBA.
4. 50.01 to 150.00 kVA: 50 dBA for K-factors of 4dBA.
5. 150.01 to 300.00 kVA: 55 dBA for K-factors of 4dBA.

2.5 IDENTIFICATION

A. Nameplates: Engraved, laminated-acrylic or melamine plastic signs for each distribution transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Section 26 0553 "Identification for Electrical Systems."

B. Nameplates: Self-adhesive label for each distribution transformer. Self-adhesive labels are specified in Section 26 0553 "Identification for Electrical Systems."

2.6 SOURCE QUALITY CONTROL

A. Test and inspect transformers according to IEEE C57.12.01 and IEEE C57.12.91.

1. Resistance measurements of all windings at rated voltage connections and at all tap connections.
2. Ratio tests at rated voltage connections and at all tap connections.
3. Phase relation and polarity tests at rated voltage connections.
4. No load losses, and excitation current and rated voltage at rated voltage connections.

5. Impedance and load losses at rated current and rated frequency at rated voltage connections.
6. Applied and induced tensile tests.
7. Regulation and efficiency at rated load and voltage.
8. Insulation-Resistance Tests:

    a. High-voltage to ground.
    b. Low-voltage to ground.
    c. High-voltage to low-voltage.

9. Temperature tests.

B. Factory Sound-Level Tests: Conduct sound-level tests on equipment for this Project.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.

B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.

C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

D. Verify that ground connections are in place and requirements in Section 26 0526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.

E. Environment: Enclosures shall be rated for the environment in which they are located. Covers for NEMA 250, Type 4X enclosures shall not cause accessibility problems.

F. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install wall-mounted transformers level and plumb with wall brackets fabricated from design drawings signed and sealed by a licensed structural engineer.

1. Coordinate installation of wall-mounted and structure-hanging supports with actual transformer provided.
2. Brace wall-mounted transformers as specified in project’s seismic criteria.

B. Install transformers level and plumb on a concrete base with vibration-dampening supports. Locate transformers away from corners and not parallel to adjacent wall surface.

C. Construct concrete bases according to Section 03 3000 "Cast-in-Place Concrete" or Section 03 3053 "Miscellaneous Cast-in-Place Concrete" and anchor floor-mounted transformers according to manufacturer's written instructions, seismic codes applicable to Project, and requirements in Section 26 0529 "Hangers and Supports for Electrical Systems."

1. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

D. Secure transformer to concrete base according to manufacturer's written instructions.

E. Secure covers to enclosure and tighten all bolts to manufacturer-recommended torques to reduce noise generation.

F. Remove shipping bolts, blocking, and wedges.

3.3 CONNECTIONS

A. Ground equipment according to Section 26 0526 "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."

C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

D. Provide flexible connections at all conduit and conductor terminations and supports to eliminate sound and vibration transmission to the building structure.

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections with the assistance of a factory-authorized service representative.

B. Small (Up to 167-kVA Single-Phase or 500-kVA Three-Phase) Dry-Type Transformer Field Tests:

1. Visual and Mechanical Inspection.

a. Inspect physical and mechanical condition.
b. Inspect anchorage, alignment, and grounding.
c. Verify that resilient mounts are free and that any shipping brackets have been removed.
d. Verify the unit is clean.
e. Perform specific inspections and mechanical tests recommended by manufacturer.
f. Verify that as-left tap connections are as specified.
g. Verify the presence of surge arresters and that their ratings are as specified.

2. Electrical Tests:

    a. Measure resistance at each winding, tap, and bolted connection.
    b. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index: the value of the index shall not be less than 1.0.
    c. Perform turns-ratio tests at all tap positions. Test results shall not deviate by more than one-half percent from either the adjacent coils or the calculated ratio. If test fails, replace the transformer.
    d. Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.

C. Large (Larger Than 167-kVA Single Phase or 500-kVA Three Phase) Dry-Type Transformer Field Tests:

1. Visual and Mechanical Inspection:

    a. Inspect physical and mechanical condition.
    b. Inspect anchorage, alignment, and grounding.
    c. Verify that resilient mounts are free and that any shipping brackets have been removed.
    d. Verify the unit is clean.
    e. Perform specific inspections and mechanical tests recommended by manufacturer.
    f. Verify that as-left tap connections are as specified.
    g. Verify the presence of surge arresters and that their ratings are as specified.

2. Electrical Tests:

    a. Measure resistance at each winding, tap, and bolted connection.
    b. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index: the value of the index shall not be less than 1.0.
    c. Perform power-factor or dissipation-factor tests on all windings.
    d. Perform turns-ratio tests at all tap positions. Test results shall not deviate by more than one-half percent from either the adjacent coils or the calculated ratio. If test fails, replace the transformer.
    e. Perform an excitation-current test on each phase.
    f. Perform an applied voltage test on all high- and low-voltage windings to ground. See IEEE C57.12.91, Sections 10.2 and 10.9.
    g. Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.

D. Remove and replace units that do not pass tests or inspections and retest as specified above.

E. Infrared Scanning: Two months after Substantial Completion, perform an infrared scan of transformer connections.

1. Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.

2. Perform two follow-up infrared scans of transformers, one at four months and the other at 11 months after Substantial Completion.
3. Prepare a certified report identifying transformer checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.

F. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

3.5 ADJUSTING

A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 5 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.

B. Output Settings Report: Prepare a written report recording output voltages and tap settings.

3.6 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION 26 2213

SECTION 26 2413 - SWITCHBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Service and distribution switchboards rated 600 V and less.
2. Surge protection devices.
3. Disconnecting and overcurrent protective devices.
4. Instrumentation.
5. Control power.
6. Accessory components and features.
7. Identification.
8. Mimic bus.

1.3 RELATED SECTIONS

A. Section 26 0574 "Overcurrent Protective Device Arc-Flash Study" for arc-flash study and arc-flash label requirements.

1.4 ACTION SUBMITTALS

A. Product Data: For each switchboard, overcurrent protective device, surge protection device, ground-fault protector, accessory, and component.

1. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

B. Shop Drawings: For each switchboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
2. Detail enclosure types for types other than NEMA 250, Type 1.
3. Detail bus configuration, current, and voltage ratings.
4. Detail short-circuit current rating of switchboards and overcurrent protective devices.
5. Include descriptive documentation of optional barriers specified for electrical insulation and isolation.
6. Detail utility company's metering provisions with indication of approval by utility company.

7. Include evidence of NRTL listing for series rating of installed devices.
8. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
9. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.
10. Include diagram and details of proposed mimic bus.
11. Include schematic and wiring diagrams for power, signal, and control wiring.

C. Samples: Representative portion of mimic bus with specified material and finish, for color selection.

D. Delegated Design Submittal:

1. For arc-flash hazard study.
2. For arc-flash labels.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Seismic Qualification Data: Certificates, for switchboards, overcurrent protective devices, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field Quality-Control Reports:

1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For switchboards and components to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 01 7800 "Closeout Submittals" include the following:

a. Routine maintenance requirements for switchboards and all installed components.
b. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

c. Time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Potential Transformer Fuses: Equal to 10 percent of quantity installed for each size and type but no fewer than two of each size and type.
2. Control-Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
3. Fuses and Fusible Devices for Fused Circuit Breakers: Equal to 10 percent of quantity installed for each size and type but no fewer than three of each size and type.
4. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type but no fewer than three of each size and type.
5. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of quantity installed for each size and type but no fewer than three of each size and type.
6. Indicating Lights: Equal to 10 percent of quantity installed for each size and type but no less than one of each size and type.

1.8 QUALITY ASSURANCE

A. Installer Qualifications: An employer of workers qualified as defined in NEMA PB 2.1 and trained in electrical safety as required by NFPA 70E.

B. Testing Qualifications: NETA or an NRTL.

1. Testing Field Supervisor: Certified by NETA.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Deliver switchboards in sections or lengths that can be moved past obstructions in delivery path.

B. Remove loose packing and flammable materials from inside switchboards and connect factory-installed space heaters to temporary electrical service to prevent condensation.

C. Handle and prepare switchboards for installation according to NEMA PB 2.1.

1.10 FIELD CONDITIONS

A. Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving switchboards into place.

B. Environmental Limitations:

1. Do not deliver or install switchboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above switchboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:

    a. Ambient Temperature: Not exceeding 104 deg F.
    b. Altitude: Will equal the project site altitude.

C. Unusual Service Conditions: NEMA PB 2, as follows:

1. Ambient temperatures within limits specified.
2. Will equal the project site altitude.

D. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify Architect, Construction Manager no fewer than 14 days in advance of proposed interruption of electric service.
2. Indicate method of providing temporary electric service.
3. Do not proceed with interruption of electric service without Architect's, Construction Manager's, and Owner's written permission.
4. Comply with NFPA 70E.

1.11 COORDINATION

A. Coordinate layout and installation of switchboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

1.12 WARRANTY

A. Manufacturer's Warranty: Manufacturer's agrees to repair or replace surge protection devices that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Switchboards shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation. Shake-table testing shall comply with ICC-ES AC156.
2. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.2 SWITCHBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Square D
2. Siemens
3. Eaton
4. G.E.

B. Source Limitations: Obtain switchboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchboards including clearances between switchboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. Comply with NEMA PB 2.

F. Comply with NFPA 70.

G. Comply with UL 891.

H. Front-Connected, Front-Accessible Switchboards:

1. Main Devices: Panel mounted.
2. Branch Devices: Panel mounted.
3. Sections front and rear aligned.

I. Front- and Side-Accessible Switchboards:

1. Main Devices: Fixed, individually mounted.
2. Branch Devices: Panel mounted.

3. Section Alignment: Front aligned.

J. Front- and Rear-Accessible Switchboards:

1. Main Devices: Fixed, individually mounted.
2. Branch Devices: Panel and fixed, individually mounted.
3. Sections front aligned.

K. Nominal System Voltage: 480Y/277 V and 208Y/120 V.

L. Main-Bus Continuous: Amps as indicated on one-line diagram.

M. Seismic Requirements: Fabricate and test switchboards according to IEEE 344 to withstand seismic forces per project's seismic requirements.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation. Shake-table testing shall comply with ICC-ES AC156.

a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

N. Indoor Enclosures: Steel, NEMA 250, Type 1.

O. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.

P. Barriers: Between adjacent switchboard sections.

Q. Insulation and isolation for main bus of main section and main and vertical buses of feeder sections.

R. Space Heaters: Factory-installed electric space heaters of sufficient wattage in each vertical section to maintain enclosure temperature above expected dew point.

1. Space-Heater Control: Thermostats to maintain temperature of each section above expected dew point.
2. Space-Heater Power Source: Transformer, factory installed in switchboard.

S. Service Entrance Rating: Switchboards intended for use as service entrance equipment shall contain from one to six service disconnecting means with overcurrent protection, a neutral bus with disconnecting link, a grounding electrode conductor terminal, and a main bonding jumper.

T. Utility Metering Compartment: Barrier compartment and section complying with utility company's requirements; hinged sealable door; buses provisioned for mounting utility company's current transformers and potential transformers or potential taps as required by utility company. If separate vertical section is required for utility metering, match and align with basic switchboard. Provide service entrance label and necessary applicable service entrance features.

U. Customer Metering Compartment: A separate customer metering compartment and section with front hinged door, and section with front hinged door, for indicated metering, and current transformers for each meter. Current transformer secondary wiring shall be terminated on shorting-type terminal blocks. Include potential transformers having primary and secondary fuses with disconnecting means and secondary wiring terminated on terminal blocks.

V. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.

W. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.

X. Pull Box on Top of Switchboard:

1. Adequate ventilation to maintain temperature in pull box within same limits as switchboard.
2. Set back from front to clear circuit-breaker removal mechanism.
3. Removable covers shall form top, front, and sides. Top covers at rear shall be easily removable for drilling and cutting.
4. Bottom shall be insulating, fire-resistive material with separate holes for cable drops into switchboard.
5. Cable supports shall be arranged to facilitate cabling and adequate to support cables indicated, including those for future installation.

Y. Buses and Connections: Three phase, four wire unless otherwise indicated.

1. Provide phase bus arrangement A, B, C from front to back, top to bottom, and left to right when viewed from the front of the switchboard.
2. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity, silver-plated.
3. Phase- and Neutral-Bus Material: Tin-plated, high-strength, electrical-grade aluminum alloy with tin-plated aluminum circuit-breaker line connections.
4. Copper feeder circuit-breaker line connections.
5. Tin-plated aluminum feeder circuit-breaker line connections.
6. Load Terminals: Insulated, rigidly braced, runback bus extensions, of same material as through buses, equipped with compression connectors for outgoing circuit conductors. Provide load terminals for future circuit-breaker positions at full-ampere rating of circuit-breaker position.
7. Ground Bus: Minimum-size required by UL 891, hard-drawn copper of 98 percent conductivity, equipped with compression connectors for feeder and branch-circuit ground conductors.
8. Main-Phase Buses and Equipment-Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
9. Disconnect Links:

    a. Isolate neutral bus from incoming neutral conductors.
    b. Bond neutral bus to equipment-ground bus for switchboards utilized as service equipment or separately derived systems.

10. Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with compression connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.

11. Isolation Barrier Access Provisions: Permit checking of bus-bolt tightness.

Z. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

AA. Bus-Bar Insulation: Factory-applied, flame-retardant, tape wrapping of individual bus bars or flame-retardant, spray-applied insulation. Minimum insulation temperature rating of 105 deg C.

BB. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components including instruments and instrument transformers.

2.3 SURGE PROTECTION DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Advanced Protection Technologies Inc. (APT).
2. Eaton.
3. General Electric Company.
4. SIEMENS Industry, Inc.; Energy Management Division.

B. SPDs: Comply with UL 1449, Type 2.

C. SPDs: Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1449, Type 2.

D. Features and Accessories:

1. Integral disconnect switch.
2. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
3. Indicator light display for protection status.
4. Form-C contacts rated at 5A and 250-V ac one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
5. Surge counter.

E. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 250kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.

F. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V and or 208Y/120 V, three-phase, four-wire circuits shall not exceed the following:

1. Line to Neutral: 1200 V for 480Y/277 V and 700 V for 208Y/120 V.
2. Line to Ground: 1200 V for 480Y/277 V and 1200 V for 208Y/120 V.
3. Line to Line: 2000 V for 480Y/277 V and 1000 V for 208Y/120 V.

G. Protection modes and UL 1449 VPR for 240/120 V, single-phase, three-wire circuits shall not exceed the following:

1. Line to Neutral: 700 V.
2. Line to Ground: 1000 V.
3. Line to Line: 1000 V.

H. SCCR: Equal or exceed 250 kA.

I. Nominal Rating: 20 kA.

2.4 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
3. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:

    a. Instantaneous trip.
    b. Long- and short-time pickup levels.
    c. Long and short time adjustments.
    d. Ground-fault pickup level, time delay, and I squared t response.

4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
5. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker; trip activation on fuse opening or on opening of fuse compartment door.
6. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).
7. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).
8. MCCB Features and Accessories:

    a. Standard frame sizes, trip ratings, and number of poles.
    b. Lugs: Compression style, suitable for number, size, trip ratings, and conductor material.
    c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
    d. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
    e. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.

f. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
g. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
h. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
i. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

B. Insulated-Case Circuit Breaker (ICCB): 80percent rated, sealed, insulated-case power circuit breaker with interrupting capacity rating to meet available fault current.

1. Fixed circuit-breaker mounting.
2. Two-step, stored-energy closing.
3. Standard function, microprocessor-based trip units with interchangeable rating plug, trip indicators, and the following field-adjustable settings:

a. Instantaneous trip.
b. Time adjustments for long- and short-time pickup.
c. Ground-fault pickup level, time delay, and I squared t response.

4. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
5. Remote trip indication and control.
6. Communication Capability: Web enabled integral Ethernet communication module and embedded Web server with factory-configured Web pages (HTML file format). Provide functions and features compatible with power monitoring and control system specified in Section 260913 "Electrical Power Monitoring and Control."
7. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
8. Control Voltage: 120-V ac.

C. Bolted-Pressure Contact Switch: Operating mechanism uses rotary-mechanical-bolting action to produce and maintain high clamping pressure on the switch blade after it engages the stationary contacts.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Boltswitch, Inc.
b. Eaton.
c. SIEMENS Industry, Inc.; Energy Management Division.

2. Main-Contact Interrupting Capability: Minimum of 12 times the switch current rating.
3. Operating Mechanism: Manual handle operation to close switch; stores energy in mechanism for opening and closing.

a. Electrical Trip: Operation of lever or push-button trip switch, or trip signal from ground-fault relay or remote-control device, causes switch to open.

b. Mechanical Trip: Operation of mechanical lever, push button, or other device causes switch to open.

4. Auxiliary Switches: Factory installed, SPDT, with leads connected to terminal block, and including one set more than quantity required for functional performance indicated.
5. Service-Rated Switches: Labeled for use as service equipment.
6. Ground-Fault Relay: Comply with UL 1053; self-powered type with mechanical ground-fault indicator, test function, tripping relay with internal memory, and three-phase current transformer/sensor.

   a. Configuration: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
   b. Internal Memory: Integrates the cumulative value of intermittent arcing ground-fault currents and uses the effect to initiate tripping.
   c. No-Trip Relay Test: Permits ground-fault simulation test without tripping switch.
   d. Test Control: Simulates ground fault to test relay and switch (or relay only if "no-trip" mode is selected).

7. Open-Fuse Trip Device: Arranged to trip switch open if a phase fuse opens.

D. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.

E. Fuses are specified in Section 26 2813 "Fuses."

2.5 INSTRUMENTATION

A. Instrument Transformers: NEMA EI 21.1, and the following:

1. Potential Transformers: NEMA EI 21.1; 120 V, 60 Hz, tapped secondary; disconnecting type with integral fuse mountings. Burden and accuracy shall be consistent with connected metering and relay devices.
2. Current Transformers: NEMA EI 21.1; 5 A, 60 Hz, secondary; wound type; single secondary winding and secondary shorting device. Burden and accuracy shall be consistent with connected metering and relay devices.
3. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kVA.
4. Current Transformers for Neutral and Ground-Fault Current Sensing: Connect secondary wiring to ground overcurrent relays, via shorting terminals, to provide selective tripping of main and tie circuit breaker. Coordinate with feeder circuit-breaker, ground-fault protection.

B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:

1. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:

   a. Phase Currents, Each Phase: Plus or minus 0.5 percent.
   b. Phase-to-Phase Voltages, Three Phase: Plus or minus 0.5 percent.
   c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 0.5 percent.

d. Megawatts: Plus or minus 1 percent.
e. Megavars: Plus or minus 1 percent.
f. Power Factor: Plus or minus 1 percent.
g. Frequency: Plus or minus 0.1 percent.
h. Accumulated Energy, Megawatt Hours: Plus or minus 1 percent; accumulated values unaffected by power outages up to 72 hours.
i. Megawatt Demand: Plus or minus 1 percent; demand interval programmable from five to 60 minutes.
j. Contact devices to operate remote impulse-totalizing demand meter.

2. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.

C. Analog Meters:

1. Meters: 4-inch diameter or 6 inches square, flush or semiflush, with anti-parallax 250-degree scales and external zero adjustment.

D. Voltmeters: Cover an expanded-scale range of nominal voltage plus 10 percent.

E. Instrument Switches: Rotary type with off position.

1. Voltmeter Switches: Permit reading of all phase-to-phase voltages and, where a neutral is indicated, phase-to-neutral voltages.
2. Ammeter Switches: Permit reading of current in each phase and maintain current-transformer secondaries in a closed-circuit condition at all times.

F. Ammeters: 2-1/2-inch minimum size with 90- or 120-degree scale. Meter and transfer device with off position, located on overcurrent device door for indicated feeder circuits only.

G. Watt-Hour Meters and Wattmeters:

1. Comply with ANSI C12.1.
2. Three-phase induction type with two stators, each with current and potential coil, rated 5 A, 120 V, 60 Hz.
3. Suitable for connection to three- and four-wire circuits.
4. Potential indicating lamps.
5. Adjustments for light and full load, phase balance, and power factor.
6. Four-dial clock register.
7. Integral demand indicator.
8. Contact devices to operate remote impulse-totalizing demand meter.
9. Ratchets to prevent reverse rotation.
10. Removable meter with drawout test plug.
11. Semiflush mounted case with matching cover.
12. Appropriate multiplier tag.

H. Impulse-Totalizing Demand Meter:

1. Comply with ANSI C12.1.
2. Suitable for use with switchboard watt-hour meter, including two-circuit totalizing relay.
3. Cyclometer.

4. Four-dial, totalizing kilowatt-hour register.
5. Positive chart drive mechanism.
6. Capillary pen holding a minimum of one month's ink supply.
7. Roll chart with minimum 31-day capacity; appropriate multiplier tag.
8. Capable of indicating and recording five-minute integrated demand of totalized system.

2.6 CONTROL POWER

A. Control Circuits: 120-V ac, supplied through secondary disconnecting devices from control-power transformer.

B. Control Circuits: 120-V ac, supplied from remote branch circuit.

C. Control Circuits: 24V dc.

D. Electrically Interlocked Main and Tie Circuit Breakers: Two control-power transformers in separate compartments, with interlocking relays, connected to the primary side of each control-power transformer at the line side of the associated main circuit breaker. 120-V secondaries connected through automatic transfer relays to ensure a fail-safe automatic transfer scheme.

E. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.

F. Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

2.7 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

B. Portable Test Set: For testing functions of solid-state trip devices without removing from switchboard. Include relay and meter test plugs suitable for testing switchboard meters and switchboard class relays.

C. Portable Circuit-Breaker Lifting Device: Floor-supported, roller-based, elevating carriage arranged for movement of circuit breakers in and out of compartments for present and future circuit breakers.

D. Overhead Circuit-Breaker Lifting Device: Mounted at top front of switchboard, with hoist and lifting yokes matching each drawout circuit breaker.

E. Spare-Fuse Cabinet: Suitably identified, wall-mounted, lockable, compartmented steel box or cabinet. Arrange for wall mounting.

F. Mounting Accessories: For anchors, mounting channels, bolts, washers, and other mounting accessories, comply with the project’s seismic or manufacturer's instructions.

2.8 IDENTIFICATION

A. Mimic Bus: Entire single-line switchboard bus work, as depicted on factory record drawing, on a photoengraved nameplate.

1. Nameplate: At least 0.032-inch-thick anodized aluminum, located at eye level on front cover of the switchboard incoming service section.

B. Mimic Bus: Entire single-line switchboard bus work, as depicted on factory record drawing, on an engraved laminated-plastic (Gravoply) nameplate.

1. Nameplate: At least 0.0625-inch-thick laminated plastic (Gravoply), located at eye level on front cover of the switchboard incoming service section.

C. Mimic Bus: Continuously integrated mimic bus factory applied to front of switchboard. Arrange in single-line diagram format, using symbols and letter designations consistent with final mimic-bus diagram.

D. Coordinate mimic-bus segments with devices in switchboard sections to which they are applied. Produce a concise visual presentation of principal switchboard components and connections.

E. Presentation Media: Painted graphics in color contrasting with background color to represent bus and components, complete with lettered designations.

F. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Receive, inspect, handle, and store switchboards according to NEMA PB 2.1.

1. Lift or move panelboards with spreader bars and manufacturer-supplied lifting straps following manufacturer's instructions.
2. Use rollers, slings, or other manufacturer-approved methods if lifting straps are not furnished.
3. Protect from moisture, dust, dirt, and debris during storage and installation.
4. Install temporary heating during storage per manufacturer's instructions.

B. Examine switchboards before installation. Reject switchboards that are moisture damaged or physically damaged.

C. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance of the Work or that affect the performance of the equipment.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install switchboards and accessories according to NEMA PB 2.1.

B. Equipment Mounting: Install switchboards on concrete base, 4-inch nominal thickness. Comply with requirements for concrete base specified in Section 03 3000 "Cast-in-Place Concrete."

1. Install conduits entering underneath the switchboard, entering under the vertical section where the conductors will terminate. Install with couplings flush with the concrete base. Extend 2 inches above concrete base after switchboard is anchored in place.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
3. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to switchboards.
6. Anchor switchboard to building structure at the top of the switchboard if required or recommended by the manufacturer.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, straps and brackets, and temporary blocking of moving parts from switchboard units and components.

D. Comply with mounting and anchoring requirements for this project’s seismic criteria.

E. Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.

F. Install filler plates in unused spaces of panel-mounted sections.

G. Install overcurrent protective devices, surge protection devices, and instrumentation.

1. Set field-adjustable switches and circuit-breaker trip ranges.

H. Install spare-fuse cabinet.

I. Comply with NECA 1.

3.3 CONNECTIONS

A. Bond conduits entering underneath the switchboard to the equipment ground bus with a bonding conductor sized per NFPA 70.

B. Support and secure conductors within the switchboard according to NFPA 70.

C. Extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.

3.4 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."

B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."

C. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Acceptance Testing:

    a. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit. Open control and metering circuits within the switchboard, and remove neutral connection to surge protection and other electronic devices prior to insulation test. Reconnect after test.
    b. Test continuity of each circuit.

2. Test ground-fault protection of equipment for service equipment per NFPA 70.
3. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
4. Correct malfunctioning units on-site where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
5. Perform the following infrared scan tests and inspections, and prepare reports:

    a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchboard. Remove front panels so joints and connections are accessible to portable scanner.
    b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchboard 11 months after date of Substantial Completion.
    c. Instruments and Equipment:

        1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

6. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

B. Switchboard will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Section 26 0573 "Overcurrent Protective Device Coordination Study."

3.7 PROTECTION

A. Temporary Heating: Apply temporary heat, to maintain temperature according to manufacturer's written instructions, until switchboard is ready to be energized and placed into service

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories, and to use and reprogram microprocessor-based trip, monitoring, and communication units.

END OF SECTION 26 2413

SECTION 26 2416 - PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Distribution panelboards.
2. Lighting and appliance branch-circuit panelboards.
3. Load centers.
4. Electronic-grade panelboards.

1.3 DEFINITIONS

A. ATS: Acceptance testing specification.

B. GFCI: Ground-fault circuit interrupter.

C. GFEP: Ground-fault equipment protection.

D. HID: High-intensity discharge.

E. MCCB: Molded-case circuit breaker.

F. SPD: Surge protective device.

G. VPR: Voltage protection rating.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of panelboard.

1. Include materials, switching and overcurrent protective devices, SPDs, accessories, and components indicated.
2. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each panelboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details.

2. Show tabulations of installed devices with nameplates, conductor termination sizes, equipment features, and ratings.
3. Detail enclosure types including mounting and anchorage, environmental protection, knockouts, corner treatments, covers and doors, gaskets, hinges, and locks.
4. Detail bus configuration, current, and voltage ratings.
5. Short-circuit current rating of panelboards and overcurrent protective devices.
6. Include evidence of NRTL listing for series rating of installed devices.
7. Include evidence of NRTL listing for SPD as installed in panelboard.
8. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
9. Include wiring diagrams for power, signal, and control wiring.
10. Key interlock scheme drawing and sequence of operations.
11. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device. Include an Internet link for electronic access to downloadable PDF of the coordination curves.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01 7800 "Closeout Submittals" include the following:

1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Keys: Two spares for each type of panelboard cabinet lock.
2. Circuit Breakers Including GFCI and GFEP Types: Two spares for each panelboard.
3. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
4. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

1.8 QUALITY ASSURANCE

A. Manufacturer Qualifications: ISO 9001 or 9002 certified.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.

B. Handle and prepare panelboards for installation according to NEMA PB 1.

1.10 FIELD CONDITIONS

A. Environmental Limitations:

1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:

    a. Ambient Temperature: Not exceeding minus 22 deg. F to plus 104 deg. F.
    b. Altitude: Not exceeding this project site elevation in feet.

B. Service Conditions: NEMA PB 1, usual service conditions, as follows:

1. Ambient temperatures within limits specified.
2. Not exceeding this project site elevation in feet.

C. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify Architect, Construction Manager, and Owner no fewer than 14 days in advance of proposed interruption of electric service.
2. Do not proceed with interruption of electric service without Architect's, Construction Manager's, and Owner's written permission.
3. Comply with NFPA 70E.

1.11 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace panelboards that fail in materials or workmanship within specified warranty period.

1. Panelboard Warranty Period: 24 months from date of Substantial Completion.

B. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace SPD that fails in materials or workmanship within specified warranty period.

1. SPD Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PANELBOARDS AND LOAD CENTERS COMMON REQUIREMENTS

A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems."

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Comply with NEMA PB 1.

E. Comply with NFPA 70.

F. Enclosures: Flush and Surface-mounted, dead-front cabinets.

1. Rated for environmental conditions at installed location.

a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
b. Outdoor Locations: NEMA 250, Type 3R.
c. Kitchen/Wash-Down Areas: NEMA 250, Type 4X.
d. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
e. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.

2. Height: 84 inches maximum.
3. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box. Trims shall cover all live parts and shall have no exposed hardware.
4. Door in Door: Door within trim cover. Trims shall cover all live parts and shall have no exposed hardware. Inner door will be keyed lockable. Provide a minimum of two keys per panel, keyed the same.
5. Skirt for Surface-Mounted Panelboards: Same gauge and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.
6. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
7. Finishes:

a. Panels and Trim: galvanized steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
b. Back Boxes: Same finish as panels and trim.
c. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components.

G. Incoming Mains:

1. Location: Convertible between top and bottom.
2. Main Breaker: Main lug interiors up to 400 amperes shall be field convertible to main breaker.

H. Phase, Neutral, and Ground Buses:

1. Material: Hard-drawn copper, 98 percent conductivity.

a. Plating shall run entire length of bus.
b. Bus shall be fully rated the entire length.

2. Interiors shall be factory assembled into a unit. Replacing switching and protective devices shall not disturb adjacent units or require removing the main bus connectors.
3. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
4. Isolated Ground Bus: Adequate for branch-circuit isolated ground conductors; insulated from box.
5. Full-Sized Neutral: Equipped with full-capacity bonding strap for service entrance applications. Mount electrically isolated from enclosure. Do not mount neutral bus in gutter.
6. Extra-Capacity Neutral Bus: Neutral bus rated 200 percent of phase bus and listed and labeled by an NRTL acceptable to authority having jurisdiction, as suitable for nonlinear loads in electronic-grade panelboards and others designated on Drawings. Connectors shall be sized for double-sized or parallel conductors as indicated on Drawings. Do not mount neutral bus in gutter.
7. Split Bus: Vertical buses divided into individual vertical sections.

I. Conductor Connectors: Suitable for use with conductor material and sizes.

1. Material: Hard-drawn copper, 98 percent conductivity.
2. Terminations shall allow use of 75 deg C rated conductors without derating.
3. Size: Lugs suitable for indicated conductor sizes, with additional gutter space, if required, for larger conductors.
4. Main and Neutral Lugs: Compression type, with a lug on the neutral bar for each pole in the panelboard.
5. Ground Lugs and Bus-Configured Terminators: Compression type, with a lug on the bar for each pole in the panelboard.
6. Feed-Through Lugs: Compression type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
7. Sub feed (Double) Lugs: Compression type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.

8. Gutter-Tap Lugs: Compression type suitable for use with conductor material and with matching insulating covers. Locate at same end of bus as incoming lugs or main device.
9. Extra-Capacity Neutral Lugs: Rated 200 percent of phase lugs mounted on extra-capacity neutral bus.

J. NRTL Label: Panelboards or load centers shall be labeled by an NRTL acceptable to authority having jurisdiction for use as service equipment with one or more main service disconnecting and overcurrent protective devices. Panelboards or load centers shall have meter enclosures, wiring, connections, and other provisions for utility metering. Coordinate with utility company for exact requirements.

K. Future Devices: Panelboards or load centers shall have mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

1. Percentage of Future Space Capacity: 20 percent.

L. Panelboard Short-Circuit Current Rating: Rated for series-connected system with integral or remote upstream overcurrent protective devices and labeled by an NRTL. Include label or manual with size and type of allowable upstream and branch devices listed and labeled by an NRTL for series-connected short-circuit rating.

1. Panelboards rated 240 V or less shall have short-circuit ratings as shown on Drawings, but not less than 10,000 A rms symmetrical.
2. Panelboards rated above 240 V and less than 600 V shall have short-circuit ratings as shown on Drawings, but not less than 14,000 A rms symmetrical.

M. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Assembly listed by an NRTL for 100 percent interrupting capacity.

1. Panelboards and overcurrent protective devices rated 240 V or less shall have short-circuit ratings as shown on Drawings, but not less than 10,000 A rms symmetrical.
2. Panelboards and overcurrent protective devices rated above 240 V and less than 600 V shall have short-circuit ratings as shown on Drawings, but not less than 14,000 A rms symmetrical.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

B. Surge Suppression: Factory installed as an integral part of indicated panelboards, complying with UL 1449 SPD Type 2.

2.3 POWER PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Square D
2. Siemens
3. Eaton
4. G.E.

B. Panelboards: NEMA PB 1, distribution type.

C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.

1. For doors more than 36 inches high, provide two latches, keyed alike.

D. Mains: Circuit breaker or Lugs only as indicated on plans.

E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.

F. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger than 125 A: Bolt-on circuit breakers.

G. Branch Overcurrent Protective Devices: Fused switches.

H. Contactors in Main Bus: NEMA ICS 2, Class A, electrically held, general-purpose controller, with same short-circuit interrupting rating as panelboard.

1. Internal Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.
2. External Control-Power Source: 24-V control circuit.

2.4 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Square D
2. Siemens
3. Eaton
4. G.E.

B. MCCB: Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers:

a. Inverse time-current element for low-level overloads.
b. Instantaneous magnetic trip element for short circuits.
c. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
3. Electronic Trip Circuit Breakers:

    a. RMS sensing.
    b. Field-replaceable rating plug or electronic trip.
    c. Digital display of settings, trip targets, and indicated metering displays.
    d. Multi-button keypad to access programmable functions and monitored data.
    e. Ten-event, trip-history log. Each trip event shall be recorded with type, phase, and magnitude of fault that caused the trip.
    f. Integral test jack for connection to portable test set or laptop computer.
    g. Field-Adjustable Settings:

        1) Instantaneous trip.
        2) Long- and short-time pickup levels.
        3) Long and short time adjustments.
        4) Ground-fault pickup level, time delay, and I squared T response.

4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
5. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).
6. GFEP Circuit Breakers: Class B ground-fault protection (30-mA trip).
7. Arc-Fault Circuit Interrupter Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration.
8. Subfeed Circuit Breakers: Vertically mounted.
9. MCCB Features and Accessories:

    a. Standard frame sizes, trip ratings, and number of poles.
    b. Breaker handle indicates tripped status.
    c. UL listed for reverse connection without restrictive line or load ratings.
    d. Lugs: Compression style, suitable for number, size, trip ratings, and conductor materials.
    e. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and HID lighting circuits.
    f. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
    g. Shunt Trip: 24-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
    h. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage with field-adjustable 0.1- to 0.6-second time delay.
    i. Rating Plugs: Three-pole breakers with ampere ratings greater than 150 amperes shall have interchangeable rating plugs or electronic adjustable trip units.
    j. Auxiliary Contacts: Two, SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts and "b" contacts operate in reverse of circuit-breaker contacts.
    k. Alarm Switch: Single-pole, normally open contact that actuates only when circuit breaker trips.
    l. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

m. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function with other upstream or downstream devices.
n. Multipole units enclosed in a factory assembled to operate as a single unit.
o. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.
p. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.

C. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.

1. Fuses and Spare-Fuse Cabinet: Comply with requirements specified in Section 262813 "Fuses."
2. Fused Switch Features and Accessories:

a. Standard ampere ratings and number of poles.
b. Mechanical cover interlock with a manual interlock override, to prevent the opening of the cover when the switch is in the on position. The interlock shall prevent the switch from being turned on with the cover open. The operating handle shall have lock-off means with provisions for three padlocks.
c. Auxiliary Contacts: Two normally open and normally closed contact(s) that operate with switch handle operation.

2.5 IDENTIFICATION

A. Panelboard Label: Manufacturer's name and trademark, voltage, amperage, number of phases, and number of poles shall be located on the interior of the panelboard door.

B. Breaker Labels: Faceplate shall list current rating, UL and IEC certification standards, and AIC rating.

C. Circuit Directory: Directory card inside panelboard door, mounted in metal frame with transparent protective cover.

1. Circuit directory shall identify specific purpose with detail sufficient to distinguish it from all other circuits.

D. Circuit Directory: Computer-generated circuit directory mounted inside panelboard door with transparent plastic protective cover.

1. Circuit directory shall identify specific purpose with detail sufficient to distinguish it from all other circuits.

2.6 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

B. Portable Test Set: For testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify actual conditions with field measurements prior to ordering panelboards to verify that equipment fits in allocated space in, and comply with, minimum required clearances specified in NFPA 70.

B. Receive, inspect, handle, and store panelboards according to NEMA PB 1.1.

C. Examine panelboards before installation. Reject panelboards that are damaged, rusted, or have been subjected to water saturation.

D. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Comply with NECA 1.

C. Install panelboards and accessories according to NEMA PB 1.1.

D. Equipment Mounting:

1. Install panelboards on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 03 3000 "Cast-in-Place Concrete."
2. Attach panelboard to the vertical finished or structural surface behind the panelboard.
3. Comply with requirements for seismic control devices per this project’s seismic criteria.

E. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.

F. Comply with mounting and anchoring requirements per this project’s seismic criteria.

G. Mount top of trim 90 inches above finished floor unless otherwise indicated.

H. Mount panelboard cabinet plumb and rigid without distortion of box.

I. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

J. Mount surface-mounted panelboards to steel slotted supports 5/8 inch in depth. Orient steel slotted supports vertically.

K. Install overcurrent protective devices and controllers not already factory installed.

1. Set field-adjustable, circuit-breaker trip ranges.
2. Tighten bolted connections and circuit breaker connections using calibrated torque wrench or torque screwdriver per manufacturer's written instructions.

L. Make grounding connections and bond neutral for services and separately derived systems to ground. Make connections to grounding electrodes, separate grounds for isolated ground bars, and connections to separate ground bars.

M. Install filler plates in unused spaces.

N. Stub four 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch empty conduits into raised floor space or below slab not on grade.

O. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.

P. Mount spare fuse cabinet in accessible location.

3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; install warning signs complying with requirements in Section 26 0553 "Identification for Electrical Systems."

B. Create a directory to indicate installed circuit loads after balancing panelboard loads; incorporate Owner's final room designations. Obtain approval before installing. Handwritten directories are not acceptable. Install directory inside panelboard door.

C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."

D. Device Nameplates: Label each branch circuit device in power panelboards with a nameplate complying with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."

E. Install warning signs complying with requirements in Section 26 0553 "Identification for Electrical Systems" identifying source of remote circuit.

3.4 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test for low-voltage air circuit breakers and low-voltage surge arrestors stated in NETA ATS, Paragraph 7.6 Circuit Breakers and Paragraph 7.19.1 Surge Arrestors, Low-Voltage. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Perform the following infrared scan tests and inspections and prepare reports:

    a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.
    b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.
    c. Instruments and Equipment:

        1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

B. Panelboards will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results, with comparisons of the two scans. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Section 26 0573 "Overcurrent Protective Device Coordination Study."

C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes. Prior to making circuit changes to achieve load balancing, inform Architect of effect on phase color coding.

1. Measure loads during period of normal facility operations.
2. Perform circuit changes to achieve load balancing outside normal facility operation schedule or at times directed by the Architect. Avoid disrupting services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
3. After changing circuits to achieve load balancing, recheck loads during normal facility operations. Record load readings before and after changing circuits to achieve load balancing.
4. Tolerance: Maximum difference between phase loads, within a panelboard, shall not exceed 20 percent.

3.6 PROTECTION

A. Temporary Heating: Prior to energizing panelboards, apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION 26 2416

SECTION 26 2726 - WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Straight-blade convenience, hospital-grade, isolated-ground, and tamper-resistant receptacles.
2. USB charger devices.
3. GFCI receptacles.
4. SPD receptacles.
5. Twist-locking receptacles.
6. Pendant cord-connector devices.
7. Cord and plug sets.
8. Toggle switches.
9. Decorator-style convenience.
10. Residential devices.
11. Wall plates.
12. Floor service outlets.
13. Prefabricated multi-outlet assemblies.

1.3 DEFINITIONS

A. Abbreviations of Manufacturers' Names:

1. Cooper: Cooper Wiring Devices; Division of Cooper Industries, Inc.
2. Hubbell: Hubbell Incorporated: Wiring Devices-Kellems.
3. Leviton: Leviton Mfg. Company, Inc.
4. Pass & Seymour: Pass& Seymour/Legrand.

B. BAS: Building automation system.

C. EMI: Electromagnetic interference.

D. GFCI: Ground-fault circuit interrupter.

E. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

F. RFI: Radio-frequency interference.

G. SPD: Surge protective device.

H. UTP: Unshielded twisted pair. ACTION SUBMITTALS

I. Product Data: For each type of product.

J. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.

K. Samples: One for each type of device and wall plate specified, in each color specified.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing-label warnings and instruction manuals that include labeling conditions.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Floor Service-Outlet Assemblies: One for every 10, but no fewer than one.
2. Poke-Through, Fire-Rated Closure Plugs: One for every 10 floor service outlets installed, but no fewer than two.
3. SPD Receptacles: One for every 10 of each type installed, but no fewer than two of each type.

PART 2 - PRODUCTS

2.1 GENERAL WIRING-DEVICE REQUIREMENTS

A. Wiring Devices, Components, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 70.

C. Devices that are manufactured for use with modular plug-in connectors may be substituted under the following conditions:

1. Connectors shall comply with UL 2459 and shall be made with stranding building wire.
2. Devices shall comply with the requirements in this Section.

D. Devices for Owner-Furnished Equipment:

1. Receptacles: Match plug configurations.

2. Cord and Plug Sets: Match equipment requirements.

E. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.2 STRAIGHT-BLADE RECEPTACLES

A. Duplex Convenience Receptacles: 125 V, 20 A, heavy-duty type; comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Eaton (Arrow Hart).
   b. Hubbell Incorporated; Wiring Device-Kellems.
   c. Leviton Manufacturing Co., Inc.

B. Tamper-Resistant Convenience Receptacles: 125 V, 20 A, heavy-duty type; comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596.

1. Provide tamper resistant devices in throughout school and in dormitory.

2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Eaton (Arrow Hart).
   b. Hubbell Incorporated; Wiring Device-Kellems.
   c. Leviton Manufacturing Co., Inc.

2.3 USB CHARGER DEVICES

A. Tamper-Resistant, USB Charger Receptacles: 12 V dc, 2.0 A, USB Type A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, UL 1310, and FS W-C-596.

1. Provide tamper resistant devices in throughout school and in dormitory.

2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Eaton (Arrow Hart).
   b. Hubbell Incorporated; Wiring Device-Kellems.
   c. Leviton Manufacturing Co., Inc.

3. Description: Single-piece, rivetless, nickel-plated, all-brass grounding system. Nickel-plated, brass mounting strap.
4. USB Receptacles: Single, Type A.
5. Line Voltage Receptacles: Single, two pole, three wire, and self-grounding.

2.4 GFCI RECEPTACLES

A. General Description:

1. 125 V, 20 A, heavy-duty type, straight blade, feed-through type.
2. Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, UL 943 Class A, and FS W-C-596.
3. Include indicator light that shows when the GFCI has malfunctioned and no longer provides proper GFCI protection.

B. Duplex GFCI Convenience Receptacles:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Eaton (Arrow Hart).
    b. Hubbell Incorporated; Wiring Device-Kellems.
    c. Leviton Manufacturing Co., Inc.

C. Tamper-Resistant, Duplex GFCI Convenience Receptacles:

1. Provide tamper resistant devices in throughout school and in dormitory.

2. Manufacturers: Subject to compliance with requirements, provide products by the following:

    a. Hubbell Incorporated; Wiring Device-Kellems.

2.5 TWIST-LOCKING RECEPTACLES

A. Twist-Lock, Single Convenience Receptacles: 125 V, 20 A, heavy-duty type; comply with NEMA WD 1, NEMA WD 6 Configuration L5-20R, and UL 498.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Eaton (Arrow Hart).
    b. Hubbell Incorporated; Wiring Device-Kellems.
    c. Leviton Manufacturing Co., Inc.

2.6 CORD AND PLUG SETS

A. Description:

1. Match voltage and current ratings and number of conductors to requirements of equipment being connected.
2. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and ampacity of at least 130 percent of the equipment rating.

3. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

2.7 TOGGLE SWITCHES

A. Comply with NEMA WD 1, UL 20, and FS W-S-896.

B. Switches, 120/277 V, 20 A, heavy-duty type:

1. Single Pole:

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1) Eaton (Arrow Hart).
2) Hubbell Incorporated; Wiring Device-Kellems.
3) Leviton Manufacturing Co., Inc.

2. Two Pole:

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1) Eaton (Arrow Hart).
2) Hubbell Incorporated; Wiring Device-Kellems.
3) Leviton Manufacturing Co., Inc.

3. Three Way:

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1) Eaton (Arrow Hart).
2) Hubbell Incorporated; Wiring Device-Kellems.
3) Leviton Manufacturing Co., Inc.

4. Four Way:

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1) Eaton (Arrow Hart).
2) Hubbell Incorporated; Wiring Device-Kellems.
3) Leviton Manufacturing Co., Inc.

C. Pilot-Light Switches: 120/277 V, 20 A, heavy-duty type.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Eaton (Arrow Hart).

b. Hubbell Incorporated; Wiring Device-Kellems.
c. Leviton Manufacturing Co., Inc.

2. Description: Single pole, with LED-lighted handle, illuminated when switch is off.

D. Key-Operated Switches: 120/277 V, 20 A, heavy-duty type.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Eaton (Arrow Hart).
b. Hubbell Incorporated; Wiring Device-Kellems.
c. Leviton Manufacturing Co., Inc.

2. Description: Single pole, with factory-supplied key in lieu of switch handle.

E. Single-Pole, Double-Throw, Momentary-Contact, Center-off Switches: 120/277 V, 20 A, heavy-duty type; for use with mechanically held lighting contactors.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Eaton (Arrow Hart).
b. Hubbell Incorporated; Wiring Device-Kellems.
c. Leviton Manufacturing Co., Inc.

F. Key-Operated, Single-Pole, Double-Throw, Momentary-Contact, Center-off Switches: 120/277 V, 20 A, heavy-duty type; for use with mechanically held lighting contactors, with factory-supplied key in lieu of switch handle.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Eaton (Arrow Hart).
b. Hubbell Incorporated; Wiring Device-Kellems.
c. Leviton Manufacturing Co., Inc.

2.8 WALL PLATES

A. Single and combination types shall match corresponding wiring devices.

1. Plate-Securing Screws: Metal with head color to match plate finish.
2. Material for Finished Spaces: Steel with white baked enamel, suitable for field painting.
3. Material for Unfinished Spaces: Galvanized steel
4. Material for Damp Locations: Cast aluminum with spring-loaded lift cover, and listed and labeled for use in wet and damp locations.

B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant, die-cast aluminum with lockable cover.

C. Wall plates shall be 0.040-inch smooth metal, except in the kitchens and restrooms, where cover plates shall be 0.302-inch stainless steel.

2.9 PREFABRICATED MULTIOUTLET ASSEMBLIES

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Wiremold, Legrand

B. Description:

1. Two-piece surface metal raceway, with factory-wired multi-outlet harness.
2. Components shall be products from single manufacturer designed for use as a complete, matching assembly of raceways and receptacles.

C. Raceway Material: Metal, with manufacturer's standard finish.
D. Multioutlet Harness:

1. Receptacles: 15-A, 125-V, NEMA WD 6 Configuration 5-15R receptacles complying with NEMA WD 1, UL 498, and FS W-C-596.
2. Receptacle Spacing: As indicated on plans.
3. Wiring: No. 12 AWG solid, Type THHN copper, multiple circuit, connecting alternating receptacles.

2.10 FINISHES

A. Device Color:

1. Wiring Devices Connected to Normal Power System: As selected by Architect unless otherwise indicated or required by NFPA 70 or device listing.
2. Wiring Devices Connected to Stand-by Power System: Red.
3. SPD Devices: Blue.

B. Wall Plate Color: Match device color.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.

B. Coordination with Other Trades:

1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of boxes.

2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:

1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.
2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
4. Existing Conductors:

    a. Cut back and pigtail, or replace all damaged conductors.
    b. Straighten conductors that remain and remove corrosion and foreign matter.
    c. Pigtailing existing conductors is permitted, provided the outlet box is large enough.

D. Device Installation:

1. Replace devices that have been in temporary use during construction and that were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.
10. Receptacles located in common areas, such as corridors, gymnasiums, cafeterias, and the like, shall be high-abuse type.

E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the left.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multi-gang wall plates.

H. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

3.2 GFCI RECEPTACLES

A. Install non-feed-through-type GFCI receptacles where protection of downstream receptacles is not required.

3.3 IDENTIFICATION

A. Comply with Section 26 0553 "Identification for Electrical Systems."

B. Identify each receptacle with panelboard identification and circuit number. Use hot, stamped, or engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.4 FIELD QUALITY CONTROL

A. Test Instruments: Use instruments that comply with UL 1436.

B. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Test Instruments: Use instruments that comply with UL 1436.
2. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.

D. Tests for Convenience Receptacles:

1. Line Voltage: Acceptable range is 105 to 132 V.
2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is unacceptable.
3. Ground Impedance: Values of up to 2 ohms are acceptable.
4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
5. Using the test plug, verify that the device and its outlet box are securely mounted.
6. Tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

E. Test straight-blade for the retention force of the grounding blade according to NFPA 99. Retention force shall be not less than 4 oz.

F. Wiring device will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports.

END OF SECTION 26 2726

SECTION 26 2813 - FUSES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Cartridge fuses rated 600 V ac and less for use in the following:

a. Control circuits.
b. Panelboards.
c. Switchboards.
d. Enclosed controllers.
e. Enclosed switches.

2. Spare-fuse cabinets.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for spare-fuse cabinets. Include the following for each fuse type indicated:

1. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.

a. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
b. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.

2. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
3. Current-limitation curves for fuses with current-limiting characteristics.
4. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse. Submit in electronic format suitable for use in coordination software.
5. Coordination charts and tables and related data.
6. Fuse sizes for elevator feeders and elevator disconnect switches.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01 7000 "Execution and Closeout Requirements," and/or Section 01 7800 "Closeout Submittals" include the following:

1. Ambient temperature adjustment information.
2. Current-limitation curves for fuses with current-limiting characteristics.
3. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse used on the Project. Submit in electronic format suitable for use in coordination software.
4. Coordination charts and tables and related data.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

1.6 FIELD CONDITIONS

A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F temperature or more than 100 deg F temperature>, apply manufacturer's ambient temperature adjustment factors to fuse ratings.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Bussmann, an Eaton business.
2. Edison; a brand of Bussmann by Eaton.
3. Littelfuse, Inc.

B. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

2.2 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, current-limiting, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

1. Type RK-1: 250 and or 600-V, zero- to 600-A rating, 200 kAIC, time delay.

2. Type RK-5: 250 and or 600-V, zero- to 600-A rating, 200 kAIC, time delay.
3. Type CC: 600-V, zero- to 30-A rating, 200 kAIC, fast acting.
4. Type CD: 600-V, 31- to 60-A rating, 200 kAIC, fast acting.
5. Type J: 600-V, zero- to 600-A rating, 200 kAIC, time delay.
6. Type L: 600-V, 601- to 6000-A rating, 200 kAIC, time delay.
7. Type T: 250-V, zero- to 1200-A, 600-V, zero- to 800-A rating, 200 kAIC, very fast acting.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NEMA FU 1 for cartridge fuses.

D. Comply with NFPA 70.

E. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

2.3 SPARE-FUSE CABINET

A. Characteristics: Wall-mounted steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.

1. Size: Adequate for storage of spare fuses specified with 15 percent spare capacity minimum. Cabinet will be able to hold all required spare fuses.
2. Finish: Gray, baked enamel.
3. Identification: "SPARE FUSES" in 1-1/2-inch-high letters on exterior of door.
4. Fuse Pullers: For each size of fuse, where applicable and available, from fuse manufacturer.
5. Provide three spare fuses for each fuse size installed and store them in the fuse cabinet.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.

B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.

C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FUSE APPLICATIONS

A. Cartridge Fuses:

1. Feeders: Class L, fast acting, Class RK1, fast acting, lass RK1, time delay.
2. Motor Branch Circuits: Class RK1, Class CC, motor duty, time delay.
3. Large Motor Branch (601-4000 A): Class L, time delay.
4. Power Electronics Circuits: Class T, fast acting.
5. Other Branch Circuits: Class RK1, time delay, Class RK5, time delay, Class J, fast acting, Class J, time delay, Class CC, fast acting.
6. Control Transformer Circuits: Class CC, time delay, control transformer duty.
7. Provide open-fuse indicator fuses or fuse covers with open fuse indication.

3.3 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

B. Install spare-fuse cabinet(s) in location shown on the Drawings or as indicated in the field by Architect.

3.4 IDENTIFICATION

A. Install labels complying with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems" and indicating fuse replacement information inside of door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION 26 2813

SECTION 26 2816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Fusible switches.
2. Nonfusible switches.
3. Receptacle switches.
4. Shunt trip switches.
5. Molded-case circuit breakers (MCCBs).
6. Molded-case switches.
7. Enclosures.

1.3 DEFINITIONS

A. NC: Normally closed.

B. NO: Normally open.

C. SPDT: Single pole, double throw.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include nameplate ratings, dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

1. Enclosure types and details for types other than NEMA 250, Type 1.
2. Current and voltage ratings.
3. Short-circuit current ratings (interrupting and withstand, as appropriate).
4. Include evidence of a nationally recognized testing laboratory (NRTL) listing for series rating of installed devices.
5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
6. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device. Provide in PDF format.

B. Shop Drawings: For enclosed switches and circuit breakers.

1. Include plans, elevations, sections, details, and attachments to other work.
2. Include wiring diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified testing agency.

B. Seismic Qualification Certificates: For enclosed switches and circuit breakers, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 01 7800 "Closeout Submittals" include the following:

a. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
b. Time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device. Provide in PDF format.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
2. Fuse Pullers: Two for each size and type.

1.8 QUALITY ASSURANCE

A. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

1.9 FIELD CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not less than minus 22 deg F and not exceeding 104 deg F.
2. Altitude: Not exceeding 6600 feet.

1.10 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: One year from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Enclosed switches and circuit breakers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.2 GENERAL REQUIREMENTS

A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single manufacturer.

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

D. Comply with NFPA 70.

2.3 FUSIBLE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Square D.
2. Siemens
3. Eaton
4. G.E.

B. Type HD, Heavy Duty:

1. Single throw.
2. Three pole.
3. 600-V ac.
4. 1200 A and smaller.
5. UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses.
6. Lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Isolated Ground Kit: Internally mounted; insulated, labeled for copper and aluminum neutral conductors.
4. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
5. Auxiliary Contact Kit: NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating - 24-V ac
6. Hookstick Handle: Allows use of a hookstick to operate the handle.
7. Lugs: Compression type, suitable for number, size, and conductor material.
8. Service-Rated Switches: Labeled for use as service equipment.

2.4 NONFUSIBLE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Square D.
2. Siemens
3. Eaton
4. G.E.

B. Type GD, General Duty, Three Pole, Single Throw, 240-V ac, 600 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.

C. Type HD, Heavy Duty, Three Pole, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

D. Type HD, Heavy Duty, Six Pole, Single Throw, 600-V ac, 200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

E. Type HD, Heavy Duty, Three Pole, Double Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

F. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Isolated Ground Kit: Internally mounted; insulated, labeled for copper and aluminum neutral conductors.
4. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
5. Auxiliary Contact Kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating - 24-V ac.
6. Hookstick Handle: Allows use of a hookstick to operate the handle.
7. Lugs: Compression type, suitable for number, size, and conductor material.
8. Service-Rated Switches: Labeled for use as service equipment.

2.5 MOLDED-CASE CIRCUIT BREAKERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Square D.
2. Siemens
3. Eaton
4. G.E.

B. Circuit breakers shall be constructed using glass-reinforced insulating material. Current carrying components shall be completely isolated from the handle and the accessory mounting area.

C. Circuit breakers shall have a toggle operating mechanism with common tripping of all poles, which provides quick-make, quick-break contact action. The circuit-breaker handle shall be over center, be trip free, and reside in a tripped position between on and off to provide local trip indication. Circuit-breaker escutcheon shall be clearly marked on and off in addition to providing international I/O markings. Equip circuit breaker with a push-to-trip button, located on the face of the circuit breaker to mechanically operate the circuit-breaker tripping mechanism for maintenance and testing purposes.

D. The maximum ampere rating and UL, IEC, or other certification standards with applicable voltage systems and corresponding interrupting ratings shall be clearly marked on face of circuit breaker. Circuit breakers shall be rated as indicated on the Drawings. Circuit breaker/circuit

breaker combinations for series connected interrupting ratings shall be listed by UL as recognized component combinations. Any series rated combination used shall be marked on the end-use equipment along with the statement "Caution - Series Rated System. _____ Amps Available. Identical Replacement Component Required."

E. MCCBs shall be equipped with a device for locking in the isolated position.

F. Lugs shall be suitable for 140 deg F rated wire on 125-A circuit breakers and below.

G. Standard: Comply with UL 489 with interrupting capacity to comply with available fault currents.

H. Thermal-Magnetic Circuit Breakers: Inverse time-current thermal element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

I. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.

J. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:

1. Instantaneous trip.
2. Long- and short-time pickup levels.
3. Long- and short-time time adjustments.
4. Ground-fault pickup level, time delay, and I-squared t response.

K. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller, and let-through ratings less than NEMA FU 1, RK-5.

L. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker and trip activation on fuse opening or on opening of fuse compartment door.

M. Ground-Fault Circuit-Interrupter (GFCI) Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).

N. Ground-Fault Equipment-Protection (GFEP) Circuit Breakers: With Class B ground-fault protection (30-mA trip).

O. Features and Accessories:

1. Standard frame sizes, trip ratings, and number of poles.
2. Lugs: Compression type, suitable for number, size, trip ratings, and conductor material.
3. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.
4. Ground-Fault Protection: Comply with UL 1053; integrally mounted, self-powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.

5. Communication Capability: Universal-mounted communication module with functions and features compatible with power monitoring and control system, specified in Section 260913 "Electrical Power Monitoring and Control."
6. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
7. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
8. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
9. Alarm Switch: One NO and NC contact that operates only when circuit breaker has tripped.
10. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
11. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
12. Electrical Operator: Provide remote control for on, off, and reset operations.
13. Accessory Control Power Voltage: Integrally mounted, self-powered; 24-V ac

2.6 MOLDED-CASE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Square D.
2. Siemens
3. Eaton
4. G.E.

B. Description: MCCB with fixed, high-set instantaneous trip only, and short-circuit withstand rating equal to equivalent breaker frame size interrupting rating.

C. Standard: Comply with UL 489 with interrupting capacity to comply with available fault currents.

D. Features and Accessories:

1. Standard frame sizes and number of poles.
2. Lugs:

    a. Compression type, suitable for number, size, trip ratings, and conductor material.
    b. Lugs shall be suitable for 140 deg F rated wire on 125-A circuit breakers and below rating in NFPA 70.

3. Ground-Fault Protection: Comply with UL 1053; remote-mounted and powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
4. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
5. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.

6. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic switch contacts, "b" contacts operate in reverse of switch contacts.
7. Alarm Switch: One NO and NC contact that operates only when switch has tripped.
8. Key Interlock Kit: Externally mounted to prohibit switch operation; key shall be removable only when switch is in off position.
9. Zone-Selective Interlocking: Integral with ground-fault shunt trip unit; for interlocking ground-fault protection function.
10. Electrical Operator: Provide remote control for on, off, and reset operations.
11. Accessory Control Power Voltage: Integrally mounted, self-powered; 24-V ac

2.7 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: UL 489, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

B. Enclosure Finish: The enclosure shall be finished with gray baked enamel paint, electrodeposited on cleaned, phosphatized steel (NEMA 250 Type 1).

C. Conduit Entry: NEMA 250 Types 4, 4X, and 12 enclosures shall contain no knockouts. NEMA 250 Types 7 and 9 enclosures shall be provided with threaded conduit openings in both endwalls.

D. Operating Mechanism: The circuit-breaker operating handle shall be directly operable through the front cover of the enclosure (NEMA 250 Type 1). The cover interlock mechanism shall have an externally operated override. The override shall not permanently disable the interlock mechanism, which shall return to the locked position once the override is released. The tool used to override the cover interlock mechanism shall not be required to enter the enclosure in order to override the interlock.

E. Enclosures designated as NEMA 250 Type 4, 4X stainless steel, 12, or 12K shall have a dual cover interlock mechanism to prevent unintentional opening of the enclosure cover when the circuit breaker is ON and to prevent turning the circuit breaker ON when the enclosure cover is open.

F. NEMA 250 Type 7/9 enclosures shall be furnished with a breather and drain kit to allow their use in outdoor and wet location applications.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

1. Commencement of work shall indicate Installer's acceptance of the areas and conditions as satisfactory.

3.2 PREPARATION

A. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify Architect, Construction Manager, Owner no fewer than 14 days in advance of proposed interruption of electric service.
2. Indicate method of providing temporary electric service.
3. Do not proceed with interruption of electric service without Architect's, Construction Manager's, Owner's written permission.
4. Comply with NFPA 70E.

3.3 INSTALLATION

A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

C. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

D. Temporary Lifting Provisions: Remove temporary lifting of eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

E. Install fuses in fusible devices.

F. Comply with NFPA 70 and NECA 1.

3.4 IDENTIFICATION

A. Comply with requirements in Section 26 0553 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.5 FIELD QUALITY CONTROL

A. Perform tests and inspections with the assistance of a factory-authorized service representative.

B. Tests and Inspections for Switches:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.

b. Inspect anchorage, alignment, grounding, and clearances.
c. Verify that the unit is clean.
d. Verify blade alignment, blade penetration, travel stops, and mechanical operation.
e. Verify that fuse sizes and types match the Specifications and Drawings.
f. Verify that each fuse has adequate mechanical support and contact integrity.
g. Inspect bolted electrical connections for high resistance using one of the two following methods:

1) Use a low-resistance ohmmeter.

a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.

2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.

a) Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.

h. Verify that operation and sequencing of interlocking systems is as described in the Specifications and shown on the Drawings.
i. Verify correct phase barrier installation.
j. Verify lubrication of moving current-carrying parts and moving and sliding surfaces.

2. Electrical Tests:

a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
b. Measure contact resistance across each switchblade fuseholder. Drop values shall not exceed the high level of the manufacturer's published data. If manufacturer's published data are not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
c. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1 from the NETA ATS. Investigate values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.
d. Measure fuse resistance. Investigate fuse-resistance values that deviate from each other by more than 15 percent.
e. Perform ground fault test according to NETA ATS 7.14 "Ground Fault Protection Systems, Low-Voltage."

C. Tests and Inspections for Molded Case Circuit Breakers:

1. Visual and Mechanical Inspection:

    a. Verify that equipment nameplate data are as described in the Specifications and shown on the Drawings.
    b. Inspect physical and mechanical condition.
    c. Inspect anchorage, alignment, grounding, and clearances.
    d. Verify that the unit is clean.
    e. Operate the circuit breaker to ensure smooth operation.
    f. Inspect bolted electrical connections for high resistance using one of the two following methods:

        1) Use a low-resistance ohmmeter.

            a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.

        2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.

            a) Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.

    g. Inspect operating mechanism, contacts, and chutes in unsealed units.
    h. Perform adjustments for final protective device settings in accordance with the coordination study.

2. Electrical Tests:

    a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
    b. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with circuit breaker closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1 from the NETA ATS. Investigate values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.
    c. Perform a contact/pole resistance test. Drop values shall not exceed the high level of the manufacturer's published data. If manufacturer's published data are not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
    d. Perform insulation resistance tests on all control wiring with respect to ground. Applied potential shall be 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable. Test duration shall be one minute. For units with solid state components, follow manufacturer's recommendation. Insulation resistance values shall be no less than two megohms.
    e. Determine the following by primary current injection:

1) Long-time pickup and delay. Pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
2) Short-time pickup and delay. Short-time pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
3) Ground-fault pickup and time delay. Ground-fault pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
4) Instantaneous pickup. Instantaneous pickup values shall be as specified and within manufacturer's published tolerances.

f. Test functionality of the trip unit by means of primary current injection. Pickup values and trip characteristics shall be as specified and within manufacturer's published tolerances.
g. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data. Minimum pickup voltage of the shunt trip and close coils shall be as indicated by manufacturer.
h. Verify correct operation of auxiliary features such as trip and pickup indicators; zone interlocking; electrical close and trip operation; trip-free, anti-pump function; and trip unit battery condition. Reset all trip logs and indicators. Investigate units that do not function as designed.
i. Verify operation of charging mechanism. Investigate units that do not function as designed.

3. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
4. Perform the following infrared scan tests and inspections and prepare reports:

a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch and circuit breaker. Remove front panels so joints and connections are accessible to portable scanner.
b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each enclosed switch and circuit breaker 11 months after date of Substantial Completion.
c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

5. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

D. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

1. Test procedures used.
2. Include identification of each enclosed switch and circuit breaker tested and describe test results.

3. List deficiencies detected, remedial action taken, and observations after remedial action.

3.6 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Section 26 0573 "Overcurrent Protective Device Coordination Study.

END OF SECTION 26 2816

SECTION 26 2820 - GROUND-FAULT PROTECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplemental General Conditions and Division 1 Specification Sections, apply to this section.

1.2 SUMMARY

A. This section includes ground-fault sensing, relaying, tripping, and monitoring devices for installation in distribution switchboards and panelboards rated 600 V and less.

1.3 SUBMITTALS

A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.

B. Product Data for each component specified.

C. Wiring diagrams detailing wiring for power and control systems and differentiating between manufacturer-installed and field-installed wiring.

D. Qualification data for firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of architects and owners, and other information specified.

E. Field test reports indicating and interpreting test results relative to compliance with performance requirements of ground-fault protection system.

F. Maintenance data for ground-fault relay to include in the operation and maintenance manual specified in Division 1.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Engage an experienced installer to install ground-fault protection system components that is acceptable to manufacturer of switchboard or disconnect device in which installation is to be made.

B. Manufacturer Qualifications: Engage a firm experienced in manufacturing ground-fault protection components similar to those indicated for this Project and with a record of successful in-service performance.

C. Testing Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7, or a full member company of the InterNational Electrical Testing Association (NETA).

1. Testing Field Supervision: Use persons currently certified by NETA or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

D. Comply with UL 1053.

E. Comply with NFPA 70.

F. Listing and Labeling: Provide products specified in this Section that are listed and labeled.

1. The Terms "Listed" and "Labeled": As defined in the National Electrical Code, Article 100.
2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide ground-fault protection components by one of the following:

1. Cutler Hammer; Advanced Products Support Center
2. General Electric Company; Electrical Distribution and Control
3. Hi-Z Corp.
4. Siemens Energy & Automation, Inc.
5. Square D Groupe Schneider

2.2 GROUND-FAULT SENSING DEVICES

A. Current Sensors: Round- or split-core rectangular current transformers.

B. Short-Circuit Rating: 200,000 symmetrical amperes.

C. Sensor Outputs: Compatible with relay inputs.

D. Split-Core Construction: Rectangular sensors are constructed to allow installation and removal without disturbing electrical conductors being encircled.

E. Relay Test Provisions: Test winding in sensor is arranged to permit testing the operation of complete ground-fault protection system, including sensor, relay, monitor panel, and circuit-interrupting device.

2.3 RELAYS AND MONITORS

A. Ground-Fault Relay: Solid-state type that requires no external source of electrical power for relay operation.

1. Testing and Tripping Voltage: 120 VAC, from external source.
2. Interlocking: Field wiring terminals and interface devices accommodate zone-selective coordination with other ground-fault relays or with ground-fault function of electronic trip units of circuit breakers indicated for coordination.
3. Pick-up Current Sensitivity: Field adjustable from 100 to 1200 A, with calibrated dial designed to inhibit tampering with setting.
4. Time Delay: Field adjustable from instantaneous to one second, with calibrated dial designed to inhibit tampering with setting.
5. UL 1053, Class I.
6. Output Circuit: Compatible with rating of tripping coils of interrupting device.

B. Monitor Panels: Include ground-fault indicator, control-power indicator, and test and reset buttons, arranged to allow testing with and without tripping.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine equipment to receive ground-fault protection devices for compliance with installation tolerances and other conditions affecting integrity and safety of completed installation and performance of the ground-fault protection system. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install ground-fault protection devices according to manufacturer's written instructions.

B. Install sensors so they encircle power-conductor bus bars or cables symmetrically. Maintain clearances between conductors and sensor body as recommended by device manufacturer.

C. Fasten and support sensors without mechanical stress, twisting, or misalignment being exerted by clamps, supports, bus bars, or cables.

D. Install interconnecting wiring for zone-selective systems in raceway where it runs external to component enclosure. Comply with Division 26 Sections, Raceways and Boxes and Wires and Cables.

E. Connections: Tighten connectors and terminals, including screws and bolts, according to

equipment manufacturer's published torque-tightening values for equipment connectors. Where manufacturer's torque values are not indicated, use those specified in UL 486A.

3.3 FIELD QUALITY CONTROL

A. Testing: Upon completion of installation of ground-fault protection system and after electrical circuits have been energized, demonstrate capability and compliance with requirements.

1. Procedures: Perform each visual and mechanical inspection and electrical test stated in NETA ATS, Section 7.14. Certify compliance with test parameters.

B. Correct malfunctioning units at site, where possible, and retest to demonstrate compliance; otherwise, remove and replace with new units and retest.

3.4 ADJUSTING

A. Set field-adjustable pick-up and time-sensitivity values as indicated.

B. Perform short-circuit analysis and coordination study. Set field-adjustable pick-up and time-sensitivity values accordingly.

C. Coordination: Use zone-selective method with 0.1-second delay of upstream devices between upstream and downstream ground-fault protection devices and circuit-breaker electronic trip units.

END OF SECTION 26 2820

SECTION 26 3623 – AUTOMATIC TRANSFER SWITCHES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Generator and Transfer Switch System is to be included under if the Alternate gets accepted.

B. This Section includes transfer switches rated 250 V and less, including the following:

1. Automatic transfer switches

C. Related Sections include the following:

1. Division 26, Section 26 3213, Diesel Generators.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, weights, operating characteristics, furnished specialties, and accessories.

1. Technical data on all major components of all transfer switches and other products described in this section. Data is required for the transfer switch mechanism, control system, cabinet, and protective devices specifically listed for use with each transfer switch. Include steady state and fault current ratings, weights, operating characteristics, and furnished specialties and accessories.
2. Single-Line Diagram: Show connections between transfer switch, power sources, and load.

B. Shop Drawings: Dimensioned plans, elevations, sections, and details showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists for each switch specified.

1. Dimensioned outline drawings of assembly, including elevations, sections, and details including minimal clearances, conductor entry provisions, gutter space, installed features and devices and material lists for each switch specified.
2. Internal electrical wiring and control drawings.
3. Interconnection wiring diagrams, showing recommended conduit runs and point-to-point terminal connections to generator set.
4. Installation and mounting instructions, including information for proper installation of equipment to meet seismic requirements.

C. Manufacturer Seismic Qualification Certification: Submit certification that transfer switches accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:

1. Seismic certification, as required for site conditions. Seismic certifications shall be third-party certified, and based on testing. Certification based on calculations does not meet this requirement.

    a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational both during and after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Manufacturer and Supplier Qualification Data

1. The transfer switch manufacturer shall be certified to ISO 9001 International Quality Standard and shall have third party certification verifying quality assurance in design/development, production, installation, and service, in accordance with ISO 9001.
2. The manufacturer of this equipment shall have produced similar equipment for a minimum period of 10 years. When requested, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

E. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals. Include the following:

1. Features and operating sequences, both automatic and manual.
2. List of all factory settings of relays, timers and protective devices; provide setting and calibration instructions where applicable.

F. Warranty documents demonstrating compliance with the project’s contract requirements.

1.4 QUALITY ASSURANCE

A. Only approved bidders shall supply equipment provided under this contract.

B. Manufacturer Qualifications: The equipment supplier shall maintain a service center capable of providing training, parts, maintenance and emergency repairs to equipment, including transfer switch generator sets and remote monitoring equipment (if applicable) at the site within a response period of less than eight hours from time of notification.

C. Source Limitations: All transfer switches are to be obtained through one source from a single manufacturer. The generator set manufacturer shall warrant transfer switches to provide a single source of responsibility for products provided.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked as suitable for use in emergency, legally required or optional standby use as appropriate for the connected load.

E. The automatic transfer switch installation and application shall conform to the requirements of the following codes and standards:

1. Transfer switches and enclosures shall be UL 1008 listed and labeled as suitable for use in emergency, legally required, and optional standby applications.
2. CSA 282, Emergency Electrical Power Supply for Buildings, and CSA C22.2, No. 14-M91 Industrial Control Equipment
3. NFPA 70, National Electrical Code. Equipment shall be suitable for use in systems in compliance with Articles 700, 701 and 702.
4. Comply with NEMA ICS 10-1993 AC Automatic Transfer Switches
5. IBC 2006 – The transfer switch(es) shall be prototype-tested and third-party certified to comply with the requirements of IBC group III or IV, Category D/F. The equipment shall be shipped with the installation instructions necessary to attain installation compliance
6. IEEE 446 – Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications
7. EN55011, Class B Radiated Emissions and Class B Conducted Emissions
8. IEC 1000-4-5 (EN 61000-4-5) AC Surge Immunity
9. IEC 1000-4-4 (EN 61000-4-4) Fast Transients Immunity
10. IEC 1000-4-2 (EN 61000-4-2) Electrostatic Discharge Immunity
11. IEC 1000-4-3 (EN 61000-4-3) Radiated Field Immunity
12. IEC 1000-4-6 Conducted Field Immunity
13. IEC 1000-4-11 Voltage Dip Immunity
14. IEEE 62.41, AC Voltage Surge Immunity
15. IEEE 62.45, AC Voltage Surge Testing

F. Comply with NFPA 110 – Emergency and Standby Power Systems. The transfer switch shall meet all requirements for Level 1 systems, regardless of the actual circuit level.

G. The manufacturer shall warrant the material and workmanship of the transfer switch equipment for a minimum of one (2) years from registered commissioning and start-up, or eighteen (18) months from date of shipment.

H. The warranty shall be comprehensive. No deductibles shall be allowed for travel time, service hours, repair parts cost, and etc. during the minimum noted warranty period described above.

1.5 PROJECT CONDITIONS

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service:

1. Notify (Architect/Construction Manager/Owner) in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without (Architect/Construction Manager/Owner's) written permission.

3. Do not energize any new service or distribution equipment without notification and permission of the (Architect/Construction Manager/Owner).

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Basis of Design

1. Cummins

B. Equipment specifications for this Project are based on automatic transfer switches manufactured by Cummins Power Generation. Switches manufactured by others that meet the requirement of this specification are acceptable, if approved not less than two weeks before scheduled bid date. Proposals must include a line-by-line compliance statement based on this specification.

C. Transfer switch shall be Linear Motor mechanisms specifically manufactured and tested to meet applicable transfer device standards. Transfer switches utilizing molded case circuit breakers with external transfer mechanisms such as walking beams and cables do not meet the requirements of this specification and will not be accepted.

2.2 GENERAL TRANSFER-SWITCH PRODUCT REQUIREMENTS

A. Provide transfer switches in the number and ratings that are shown on the drawings. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer.

B. Fault-Current Closing and Withstand Ratings: UL 1008 WCR ratings must be specifically listed as meeting the requirements for use with protective devices at installation locations, under specified fault conditions. Withstand and closing ratings shall be based on use of the same set of contacts for the withstand test and the closing test.

C. Solid-State Controls: All settings should be accurate to +/- 2% or better over an operating temperature range of - 40 to + 60 degrees C (- 40 to + 140 degrees F).

D. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.41. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.

E. Electrical Operation: Accomplished by a non-fused, momentarily energized solenoid or electric motor operator mechanism, mechanically and electrically interlocked in both directions.

F. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.

1. Transfer switches shall be double-throw, electrically and mechanically interlocked, and mechanically held in the Source 1 and Source 2 positions.
2. Source 1 and Source 2 shall have dedicated contact mechanisms. Transfer switches with shared contact surfaces on a single wiper shaft mechanism are not acceptable.

3. Main switch contacts shall be high-pressure silver alloy. Contact assemblies shall have arc chutes for positive arc extinguishing. Arc chutes shall have insulating covers to prevent inter-phase flashover.
4. Contacts shall be operated by a high-speed electrical mechanism that causes contacts to open or close within three electrical cycles from signal.
5. The transfer switch operation shall include the ability to switch to an open position (both sources disconnected) for the purpose of load shedding from the generator set.
6. The power transfer mechanism shall include provisions for manual operation under load with the enclosure door closed. Manual operation may be electromechanical or mechanical, but must be coordinated with control function.
7. Transfer switch shall be provided with flame retardant transparent covers to allow viewing of switch contact operation but prevent direct contact with components that could be operating at line voltage levels.
8. The transfer switch shall include the mechanical and control provisions necessary to allow the device to be field-configured for operating speed. Transfer switch operation with motor loads shall be as is recommended in NEMA MG1.

    a. Phase angle monitoring/timing equipment is not an acceptable substitute for this functionality

9. Transfer switches designated on the drawings as "4-pole" shall be provided with a switched neutral pole switched which is switched simultaneously with phase poles.

G. Control: Transfer switch control shall be capable of communicating with the genset control, other switches and remote programming devices over a high-speed network interface.

H. Factory wiring: Transfer switch internal wiring shall be composed of pre-manufactured harnesses that are permanently marked for source and destination. Harnesses shall be connected to the control system by means of locking disconnect plug(s), to allow the control system to be easily disconnected and serviced without disconnecting power from the transfer switch mechanism

I. Terminals: Terminals shall be pressure type and appropriate for all field wiring. Terminal arrangement and cabinet space must be such that feeder conductors can enter from the top, side or bottom of the switch, at the installer's discretion. Control wiring shall be equipped with suitable lugs, for connection to terminal strips.

J. Enclosures: All enclosures shall be third-party certified for compliance to NEMA ICS 6 and UL 508, unless otherwise indicated:

1. The enclosure shall provide wire bend space in compliance to the latest version of NFPA70, regardless of the direction from which the conduit enters the enclosure.
2. Exterior cabinet doors shall provide complete protection for the system's internal components. Doors must have permanently mounted key-type latches. Bolted covers or doors are not acceptable.
3. Transfer switches shall be provided in enclosures that are third party certified for their intended environment per NEMA requirements.

    a. Transfer switches mounted in a controlled indoor environment shall be provided in NEMA Type 1 enclosures (IEC type IP30).

b. Transfer switches located outdoors shall be supplied in NEMA Type 3R (IEC IP34) when dust-proof and/or rain-proof enclosures are required.

2.3 AUTOMATIC TRANSFER SWITCHES

A. Comply with requirements for Level 1 equipment according to NFPA 110.

B. Indicated current ratings:

1. System voltage: As indicated.
2. Rated Amps: As indicated
3. Switched number of poles: As indicated.
4. Withstand and Closing Rating: 35,000A @ 250V
5. Enclosure Type: As indicated.
6. Main contacts shall be rated for 250AC minimum.
7. Transfer switches shall be rated to carry 100% of rated current continuously in the enclosure supplied, in ambient temperatures of -40 to +60 degrees C (-40 to +140 degrees F), relative humidity up to 95% (non-condensing), and altitudes up to 10,000 feet (3000 meters).

C. Manual Switch Operation: The power transfer mechanism shall include provisions for manual operation under load with the enclosure door closed. Manual operation may be electromechanical or mechanical, but must be coordinated with control function

D. Control: Transfer switch control shall be provided with necessary equipment and software to communicate with the genset control, other transfer switches, remote annunciation equipment, and other devices over a high speed control network.

E. Neutral Switching: Transfer switches designated on the drawings as 4-pole shall be provided with a switched neutral pole. The neutral pole shall be of the same construction and have the same ratings as the phase poles. All poles shall be switched simultaneously using a common crossbar. Substitute equipment using overlapping neutral contacts is not acceptable.

F. Automatic Transfer Switch Control Features

1. The transfer switch control system shall be configurable in the field for any operating voltage level up to 250 VAC. Voltage sensing shall be monitored based on the normal voltage at the site. Systems that utilize voltage monitoring based on standard voltage conditions that are not field configurable are not acceptable.
2. All transfer switch sensing shall be configurable from an operator panel or from a Windows XP or later PC-based service tool. Designs utilizing DIP switches or other electromechanical devices are not acceptable.
3. The transfer switch shall be configurable to accept a relay contact signal and a network signal from an external device to prevent transfer to the generator service.
4. The transfer switch shall provide a relay contact signal prior to transfer or re-transfer. The time period before and after transfer shall be adjustable in a range of 0 to 50 seconds.
5. The control system shall be designed and prototype tested for operation in ambient temperatures from - 40 degrees C to + 60 degrees C (- 40 to +140 degrees F). It shall be designed and tested to comply with the requirements of the noted voltage and RFI/EMI standards.

6. The control shall have optically isolated logic inputs, high isolation transformers for AC inputs and relays on all outputs, to provide optimum protection from line voltage surges, RFI and EMI.
7. The transfer switch network monitoring equipment, when supplied, shall be provided with a battery-based auxiliary power supply to allow monitoring of the transfer switch when both AC power sources are non-operational. The battery power supply shall be monitored for proper condition, and the transfer switch shall include an alarm condition to indicate low battery condition.

G. Transfer Switch Control Panel: The transfer switch shall have a microprocessor-based control with a sealed membrane panel incorporating pushbuttons for operator-controlled functions, and LED lamps for system status indicators. Panel indicating lamps shall include permanent labels.

1. The indicator panel LEDs shall display:

   a. Which source the load is connected to (Source 1 or Source 2)
   b. Which source or sources are available
   c. When the switch is in test/exercise mode

2. The indicator shall have pushbuttons that allow the operator to activate the following functions:

   a. Activate pre-programmed test sequence
   b. Override programmed delays, and immediately go to the next operation
   c. Reset the control by clearing any faults
   d. Test all of the LEDs by lighting them simultaneously

3. The display panel shall allow the operator to view and make adjustments:

   a. Set nominal voltage and frequency for the transfer switch
   b. Adjust voltage and frequency sensor operation set points
   c. Set up time clock functions
   d. Enable or disable control functions including program transition

H. Control Functions: Functions managed by the control shall include:

1. Solid-state under voltage sensors shall simultaneously monitor both sources. Pick-up and drop-out settings shall be adjustable.
2. Automatic controls shall signal the engine-generator set to start upon signal from normal source sensor. Solid-state time delay start, adjustable from 0 to 10 seconds (factory set at 2 seconds) shall avoid nuisance start-ups. Battery voltage starting contacts shall be silver alloy, dry type contacts, factory wired to a field wiring terminal block.
3. The switch shall transfer when the emergency source reaches the set point. Provide a solid-state time delay on transfer, adjustable from 2 to 120 seconds, factory set at 3 seconds.
4. The switch shall retransfer the load to the normal source after a time delay retransfer, adjustable from 6 seconds to 30 minutes, factory set at 5 minutes. Retransfer time delay shall be immediately bypassed if the emergency power source fails.
   Controls shall signal the engine-generator set to stop after a time delay, adjustable from 0 to 10 minutes, and factory set at 5 minutes, beginning on return to the normal source.

5. The control system shall include field adjustable provisions to control the speed of operation of the transfer switch power contacts. In addition, the control shall include a field-configurable in-phase monitor function that causes the transfer to be initiated only when the sources are in phase. When in-phase transfer is enabled and transfer does not occur within 120 seconds, the control shall automatically transfer the load using delayed transfer.
6. Provide a field-configurable exerciser clock with provisions for operating the generator set for a test period at 7, 14, 21, or 28-day intervals in either with-load or without-load configuration. Operation time of the generator set shall be field configurable. Exerciser clock functions that require setting the test time by pressing an exercise button at the desired time of exercise (only) shall not be acceptable.
7. Power for the transfer switch operation shall be derived from the source to which the load is being transferred.

I. Control Interface

1. Provide one set Form C auxiliary contacts on both sides, operated by transfer switch position, rated 10 amps 250 VAC.
2. The transfer switch shall be provided with a network communications, and configured to allow network-based communication with the transfer switch and other network system components, including the generator set(s) provided for the Project.
3. Unassigned Auxiliary Contacts: Two normally open, 1-pole, double-throw contacts for each switch position, rated 10A at 240 VAC.

J. Engine Starting Contacts

1. One isolated and normally closed, and one isolated and normally open; rated 10A at 32 VDC minimum.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Design each fastener and support to carry load indicated by seismic requirements and according to seismic-restraint details.

B. Identify components according to Division 26 Section "Identification for Electrical Systems."

C. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

3.2 CONNECTIONS

A. Wiring to Remote Components: Match type and number of cables and conductors to control and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner if necessary to accommodate required wiring.

B. Field control connections shall be made on a common terminal block that is clearly and permanently labeled.

C. Transfer switch shall be provided with AL/CU mechanical lugs sized to accept the full output rating of the switch. Lugs shall be suitable for the number and size of conductors shown on the drawings.

D. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

E. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.3 SOURCE QUALITY CONTROL

A. Prior to shipping, factory shall test and inspect components, assembled switches, and associated equipment to ensure proper operation.

B. Factory shall check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements.

C. Factory shall perform dielectric strength test complying with NEMA ICS 1.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: The supplier of the transfer switch(es) and associated equipment shall inspect, test, and adjust components, assemblies, and equipment installations, including connections, and report results in writing.

B. Manufacturer’s representative shall perform tests and inspections and prepare test reports.

C. After installing equipment and after electrical circuitry has been energized, installer shall test for compliance with requirements.

1. Perform recommended installation tests as recommended in manufacturer’s installation and service manuals.
2. After energizing circuits, demonstrate interlocking sequence and operational function for each switch.

    a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
    b. Verify time-delay settings.
    c. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.

3.5 DEMONSTRATION

A. After reconnection to existing generator, the generator and transfer switch supplier shall conduct a complete operation, basic maintenance, and emergency service seminar covering generator set and transfer switch equipment, for up to 10 people employed by the Owner.

1. The seminar shall include instruction on operation of the transfer equipment, normal testing and exercise, adjustments to the control system, and emergency operation procedures.
2. The class duration shall be at least 4 hours in length, and include practical operation with the installed equipment.

3.6 SERVICE AND SUPPORT

A. The transfer switch supplier shall maintain service parts inventory for the entire power system at a central location which is accessible to the service location 24 hours per day, 365 days per year. The inventory shall have a commercial value of $3 million or more. The manufacturer of the transfer switch shall maintain a central parts inventory to support the supplier, covering all the major components of the power system, including engines, alternators, control systems, paralleling electronics, and power transfer equipment.

B. The transfer switch shall be serviced by a local service organization that is trained and factory certified in transfer switch service. The supplier shall maintain an inventory of critical power system replacement parts in the local service location. Service vehicles shall be stocked with critical replacement parts. The service organization shall be on call 24 hours per day, 365 days per year. The service organization shall be physically located within 100 miles of the site.

C. The manufacturer shall maintain model and serial number records of each transfer switch provided for at least 20 years.

END OF SECTION 26 3623

SECTION 26 4112 - LIGHTNING PROTECTION FOR STRUCTURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes lightning protection for structures and structure elements.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: For air terminals and mounting accessories.

1. Layout of the lightning protection system, along with details of the components and cable connections to be used in the installation.
2. Include indications for use of raceway, data on how concealment requirements will be met, and calculations required by NFPA 780 for bonding of grounded and isolated metal bodies.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer and manufacturer. Include data on listing or certification by UL.

B. Certification, signed by Contractor, that roof adhesive is approved by manufacturer of roofing material.

C. Field quality-control reports.

D. Comply with recommendations in NFPA 780, Annex D, "Inspection and Maintenance of Lightning Protection Systems," for maintenance of the lightning protection system.

E. Other Informational Submittals: Plans showing non-dimensioned locations of grounding features, including the following:

1. Ground rods.
2. Ground loop conductor.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Certified by UL or LPI as a Master Installer/Designer, trained and approved for installation of units required for this Project.

B. System Certificate:

1. UL Master Label.
2. LPI System Certificate.
3. Provide ETL Master Label indicating system complies with specified requirements.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 780, "Definitions" Article.

D. All lightning protection equipment shall be installed per master label requirements.

E. A UL or equivalent Master Label shall be obtained after construction is completed.

1.6 COORDINATION

A. Coordinate installation of lightning protection with installation of other building systems and components, including electrical wiring, supporting structures and building materials, metal bodies requiring bonding to lightning protection components, and building finishes.

B. Coordinate installation of air terminals attached to roof systems with roofing manufacturer and Installer.

C. Flashings of through-roof assemblies shall comply with roofing manufacturers' specifications.

PART 2 - PRODUCTS

2.1 LIGHTNING PROTECTION SYSTEM COMPONENTS

A. Comply with UL 96 and NFPA 780.

B. Roof-Mounted Air Terminals: NFPA 780, aluminum unless otherwise indicated.

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated or comparable product by one of the following:

a. East Coast Lightning Equipment Inc.
b. ERICO International Corporation.
c. Harger.
d. Heary Bros. Lightning Protection Co. Inc.
e. Independent Protection Co.
f. Preferred Lightning Protection.
g. Robbins Lightning, Inc.
h. Thompson Lightning Protection, Inc.
i. A-C Lightning Security, Inc.

j. Approved Lightning Protection Co., Inc.
k. West Dodd Lightning Conductor Corp.
l. VFC Lightning Protection

2. Air Terminals More than 24 Inches Long: With brace attached to the terminal at not less than half the height of the terminal.
3. Air terminal bases shall be cast bronze with bo9lted pressure cable connectors, suitable for fastening to the supporting structure.
4. Single-Membrane, Roof-Mounted Air Terminals: Designed specifically for single-membrane roof system materials. Comply with requirements in roofing Sections.

C. Provide a Franklin-rod type lightning protection system. All material and conductors shall be galvanically compatible. Material acceptable for use with copper are brass, nickel, tin, and stainless steel. Materials acceptable for use with aluminum are magnesium, zinc, galvanized steel, stainless steel, and wrought iron.

D. Main and Bonding Conductors: Aluminum.

E. Ground Loop Conductor: The same size and type as the main conductor except tinned.

F. Ground Rods: Copper-clad; 3/4 inch in diameter by 10 feet long.

G. Heavy-Duty, Stack-Mounted, Lightning Protection Components: Solid copper.

H. Chemical Ground Rods:

1. Provide UL listed electrolytically enhanced ground rod(s) as shown on the drawings. Ground rod(s) to operate by hygroscopically extracting moisture from the air to activate the electrolytic process.
2. Furnish ground rod(s) fabricated from Type K copper tubing approximately 10 feet long, 2 inches in diameter, and containing a hygroscopic electrolyte material. Furnish each chemical ground rod(s) with a 24-inch long #4/0 copper pigtail, a protective cover box, and bentonite clay backfill material free of polymer sealants.
3. Minimum life expectancy: 30 Years
4. As manufactured by Lyncole Industries, Inc., LEC, Inc., Superior Grounding Systems.

I. Down-lead conductors shall be the same size and type as the main conductors if the structural steel of the building is not used.

PART 3 - EXECUTION

3.1 INSTALLATION EXAMINATION

A. Examine surfaces, areas, and conditions, with Installer present, for compliance with installation tolerances and other conditions affecting performance of lightning protection. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Conform to the most stringent requirements when more than one standard is specified.

B. Where indicated, run conductors in nonmetallic raceway, Schedule 80, minimum.

C. Install lightning protection components and systems according to UL 96A and NFPA 780.

D. Install conductors with direct paths from air terminals to ground connections. Avoid sharp bends.

E. Conceal the following conductors:

1. System conductors.
2. Down conductors.
3. Interior conductors.
4. Conductors within normal view of exterior locations at grade within 200 feet of building.

F. Cable Connections: Use crimped or bolted connections for all conductor splices and connections between conductors and other components. Use exothermic-welded connections in underground portions of the system.

G. Cable Connections: Use exothermic-welded connections for all conductor splices and connections between conductors and other components.

1. Exception: In single-ply membrane roofing, exothermic-welded connections may be used only below the roof level.

H. Air Terminals on Single-Ply Membrane Roofing: Comply with roofing membrane and adhesive manufacturer's written instructions.

I. Bond extremities of vertical metal bodies exceeding 60 feet in length to lightning protection components.

J. All down-lead conductors shall be fully concealed in PVC schedule 40 conduit within the building walls. Down-lead conductors shall be protected from physical damage or displacement for a distance of not less than 8 feet above grade.

K. Above-grade cable connections, bonding devices, cable splices, and miscellaneous connectors shall be cast bronze with bolted pressure connections to cable and shall be electrolytically compatible with the conductor type. Cast or stamped, crimped-style fittings are not acceptable for above-grade use.

L. Ground Loop: Install ground-level, potential equalization conductor and extend around the perimeter of area or item indicated.

1. Bury ground ring not less than 24 inches from building foundation.
2. Bond ground terminals to the ground loop.
3. Bond grounded building systems to the ground loop conductor within 12 feet of grade level.

M. Bond lightning protection components with intermediate-level interconnection loop conductors to grounded metal bodies of building at 60-foot intervals.

3.3 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.4 LIGHTNING PROTECTION GROUNDING ELECTRODE SYSTEM

A. Made Electrodes: Install a ground rods located 5 feet outside the building perimeter and at least 2 feet from any electrical system or communications system grounding. Install ground rods in 6-inch diameter augured holes with at least 10 feet separation between rods. Backfill hole with a slurry of ground electrode backfill material.

3.5 CORROSION PROTECTION

A. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture unless moisture is permanently excluded from junction of such materials.

B. Use conductors with protective coatings where conditions cause deterioration or corrosion of conductors.

3.6 FIELD QUALITY CONTROL

A. Notify Architect at least 48 hours in advance of inspection before concealing lightning protection components.

B. UL Inspection: Meet requirements to obtain a UL Master Label for system.

C. LPI System Inspection: Meet requirements to obtain an LPI System Certificate.

D. Periodic Inspections: Provide the services of a qualified inspector to perform periodic inspections during construction and at its completion, according to LPI-177.

E. ETL Inspection: Provide the services of ETL to inspect completed system for conformance with specified requirements.

END OF SECTION 26 4112

SECTION 26 4313 - SURGE PROTECTION FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes:

1. Type 1 surge protective devices.
2. Type 2 surge protective devices.
3. Enclosures.
4. Conductors and cables.

B. Related Requirements:

1. Section 262413 "Switchboards" for integral SPDs installed by switchboard manufacturer.
2. Section 262416 "Panelboards" for integral SPDs installed by panelboard manufacturer.
3. Section 262726 "Wiring Devices" for integral SPDs installed by receptacle manufacturer.

1.3 DEFINITIONS

A. Inominal: Nominal discharge current.

B. MCOV: Maximum continuous operating voltage.

C. Mode(s), also Modes of Protection: air of electrical connections where the VPR applies.

D. MOV: Metal-oxide varistor; an electronic component with a significant non-ohmic current-voltage characteristic.

E. NRTL: Nationally recognized testing laboratory.

F. OCPD: Overcurrent protective device.

G. SCCR: Short-circuit current rating.

H. SPD: Surge protective device.

I. Type 1 SPDs: Permanently connected SPDs intended for installation between the secondary of the service transformer and the line side of the service disconnect overcurrent device.

J. Type 2 SPDs: Permanently connected SPDs intended for installation on the load side of the service disconnect overcurrent device, including SPDs located at the branch panel.

K. Type 3 SPDs: Point of utilization SPDs.

L. VPR: Voltage protection rating.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include electrical characteristics, specialties, and accessories for SPDs.
2. NRTL certification of compliance with UL 1449.

a. Tested values for VPRs.
b. Inominal ratings.
c. MCOV, type designations.
d. OCPD requirements.
e. Manufacturer's model number.
f. System voltage.
g. Modes of protection.

1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Sample Warranty: For manufacturer's special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: For SPDs to include in maintenance manuals.

1.7 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace SPDs that fail in materials or workmanship within 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 TYPE 1 SURGE PROTECTIVE DEVICES (SPDs)

A. Source Limitations: Obtain devices from single source from single manufacturer.

B. Standards:

1. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1449, Type 1.

C. Product Options:

1. Include integral disconnect switch.
2. Include internal thermal protection that disconnects the SPD before damaging internal suppressor components.
3. Include indicator light display for protection status.
4. Include audible alarm.
5. Include NEMA ICS 5, dry Form C contacts rated at 2 A and 24 V ac for remote monitoring of protection status.
6. Include surge counter.

D. Performance Criteria:

1. MCOV: Not less than 125 percent of nominal system voltage for 208Y/120 V and 120/240 V power systems, and not less than 115 percent of nominal system voltage for 480Y/277 V power systems.
2. Peak Surge Current Rating: Minimum single-pulse surge current withstand rating per phase must not be less than 160 kA for Panelboards and 320 kA for Switchboards. Peak surge current rating must be arithmetic sum of the ratings of individual MOVs in a given mode.
3. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V and 208Y/120 V, three-phase, four-wire circuits must not exceed the following:

    a. Line to Neutral: 1200 V for 480Y/277 V and 700 V for 208Y/120 V.
    b. Line to Line: 2000 V for 480Y/277 V and 1200 V for 208Y/120 V.

4. Protection modes and UL 1449 VPR for 240/120 V, single-phase, three-wire circuits must not exceed the following:

    a. Line to Neutral: 700 V.
    b. Line to Line: 1200 V.

5. SCCR: Not less than 200 kA.
6. Inominal Rating: 20 kA.

2.2 TYPE 2 SURGE PROTECTIVE DEVICES (SPDs)

A. Source Limitations: Obtain devices from single source from single manufacturer.

B. Standards:

1. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1449, Type 2.
2. Comply with UL 1283.

C. Product Options:

1. Include LED indicator lights for power and protection status.
2. Include internal thermal protection that disconnects the SPD before damaging internal suppressor components.
3. Include NEMA ICS 5, dry Form C contacts rated at 2A and 24V ac for remote monitoring of protection status.
4. Include surge counter.

D. Performance Criteria:

1. MCOV: Not less than 125 percent of nominal system voltage for 208Y/120 V and 120/240 V power systems, and not less than 115 percent of nominal system voltage for 480Y/277 V power systems.
2. Peak Surge Current Rating: Minimum single-pulse surge current withstand rating per phase must not be less than 100 kA for panelboards and 150 kA for Switchboards kA. Peak surge current rating must be arithmetic sum of the ratings of individual MOVs in a given mode.
3. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V and 208Y/120 V, three-phase, four-wire circuits must not exceed the following:

    a. Line to Neutral: 1200 V for 480Y/277 V and 700 V for 208Y/120 V.
    b. Line to Ground: 1200 V for 480Y/277 V and 700 V for 208Y/120 V.
    c. Neutral to Ground: 1200 V for 480Y/277 V and 700 V for 208Y/120 V.
    d. Line to Line: 2000 V for 480Y/277 V and 1200 V for 208Y/120 V.

4. Protection modes and UL 1449 VPR for 240/120 V, single-phase, three-wire circuits must not exceed the following:

    a. Line to Neutral: 700 V.
    b. Line to Ground: 700 V.
    c. Neutral to Ground: 700 V.
    d. Line to Line: 1200 V.

5. SCCR: Equal or exceed 100 kA.
6. Inominal Rating: 10 kA.

2.3 TYPE 3, TYPE 4, AND TYPE 5 SURGE PROTECTIVE DEVICES (SPDs)

A. Type 3, Type 4, and Type 5 SPDs are not approved for field installation.

2.4 ENCLOSURES

A. Indoor Enclosures: NEMA 250, Type 1.

B. Outdoor Enclosures: NEMA 250, Type 3R.

2.5 CONDUCTORS AND CABLES

A. Power Wiring: Same size as SPD leads, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.

B. Provide OCPD and disconnect for installation of SPD in accordance with UL 1449 and manufacturer's written instructions.

C. Install leads between disconnects and SPDs short, straight, twisted, and in accordance with manufacturer's written instructions. Comply with wiring methods in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

1. Do not splice and extend SPD leads unless specifically permitted by manufacturer.
2. Do not exceed manufacturer's recommended lead length.
3. Do not bond neutral and ground.

D. Use crimped connectors and splices only. Wire nuts are unacceptable.

3.2 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Compare equipment nameplate data for compliance with Drawings and the Specifications.
2. Inspect anchorage, alignment, grounding, and clearances.
3. Verify that electrical wiring installation complies with manufacturer's written installation requirements.

B. SPDs that do not pass tests and inspections will be considered defective.

C. Prepare test and inspection reports.

3.3 STARTUP SERVICE

A. Complete startup checks in accordance with manufacturer's written instructions.

B. Do not perform insulation-resistance tests of the distribution wiring equipment with SPDs installed. Disconnect SPDs before conducting insulation-resistance tests; reconnect them immediately after the testing is over.

C. Energize SPDs after power system has been energized, stabilized, and tested.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to operate and maintain SPDs.

END OF SECTION 26 4313

SECTION 265119 - LED INTERIOR LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Interior solid-state luminaires that use LED technology.
2. Lighting fixture supports.

B. Related Requirements:

1. Section 260923 "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.

1.3 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color Rendering Index.

C. Fixture: See "Luminaire."

D. IP: International Protection or Ingress Protection Rating.

E. LED: Light-emitting diode.

F. Lumen: Measured output of lamp and luminaire, or both.

G. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Arrange in order of luminaire designation.
2. Include data on features, accessories, and finishes.
3. Include physical description and dimensions of luminaires.
4. Include emergency lighting units, including batteries and chargers.

5. Include life, output (lumens, CCT, and CRI), and energy efficiency data.
6. Photometric data and adjustment factors based on laboratory tests, complying with IESNA Lighting Measurements Testing and Calculation Guides, of each lighting fixture type. The adjustment factors shall be for lamps and accessories identical to those indicated for the lighting fixture as applied in this Project IES LM-79, IES LM-80 and IESNA TM-21-11.

    a. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.
    b. Testing Agency Certified Data: For indicated luminaires, photometric data certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.

7. Include lighting calculations for each space using standard reflectances and working plane height of 30" AFF for comparison to Basis of Design.

B. Shop Drawings: For nonstandard or custom luminaires.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing laboratory providing photometric data for luminaire.

B. Seismic Qualification Certificates: For luminaires, accessories, and components, from manufacturer.

1. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

C. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Product Certificates: For each type of luminaire.

E. Product Test Reports: For each luminaire, for tests performed by manufacturer and witnessed by a qualified testing agency.

F. Sample warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires and lighting systems to include in operation and maintenance manuals.

1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

1.7 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturer's laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.

B. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7, accredited under the NVLAP for Energy Efficient Lighting Products, and complying with the applicable IES testing standards.

C. Provide luminaires from a single manufacturer for each luminaire type.

D. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.9 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

B. Warranty Period: Five year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

B. Seismic Performance: Luminaires and LEDs shall be labeled vibration and shock resistant.

1. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified and the luminaire will be fully operational during and after the seismic event.

2.2 LUMINAIRE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. NRTL Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by an NRTL.

C. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

D. Recessed Fixtures: Comply with NEMA LE 4.

E. CRI of minimum 80. CCT of 3500K.

F. Rated lamp life of 50,000 hours.

G. LEDs dimmable from 100 percent to 0 percent of maximum light output.

2.3 INTERNAL LINEAR DRIVER

A. Physical Characteristics

1. Driver shall be available in an all metal-can construction for optimal thermal performance.
2. Driver shall have a slim profile with height ≤ 1 in and width ≤ 1.2 in.
3. Driver shall be provided with integral color-coded connectors.

B. Performance Requirements

1. Driver shall operate from 50/60 Hz input source of 120V through 277V with sustained variations of +/- 10% (voltage) with no damage to the Driver.
2. Driver output shall be regulated to +/- 5% across published load range.
3. Driver shall have an easy way to lower the output current, without using the dimming leads.
4. Driver shall have a Power Factor greater than 0.90 for primary application to 50% of full load rating.
5. Driver input current shall have Total Harmonic Distortion (THD) of less than 20% to 50% of full load rating.
6. Driver shall have a Class A sound rating.
7. Driver shall have a minimum operating temperature of -20C (-4F).
8. Driver shall tolerate sustained open circuit and short circuit output conditions without fail and auto-resetting without need for external fuses or trip devices.
9. Driver output ripple current shall be less than 15% measured peak-to-average, with ripple frequency >100Hz.
10. Driver performance requirements shall be met when operated to 50% of full load rating.
11. Driver shall be rated for UL Damp and Dry locations.
12. Driver shall have integral common mode and differential mode surge protection of 2.5kV(100kHz 30ohm ring wave).
13. Driver shall have integral thermal foldback to reduce driver power above rated case temperature to protect the driver if temperatures reach unacceptable levels.

14. Driver shall comply with NEMA 410 for in-rush current limits.
15. Driver shall incorporate an integral means of limiting surges to the LEDs.

C. Regulatory

1. Driver shall not contain any Polychlorinated Biphenyl (PCB).
2. Driver shall be Underwriters Laboratories (UL) recognized Class 2 per UL1310 or Canadian Standards Association (CSA) recognized Class 2 per CSA-C22.2.
3. Driver shall comply with applicable requirements of the Federal Communications Commission (FCC) rules and regulations, Title 47 CFR part 15, for Non-Consumer equipment.
4. Driver shall be RoHS compliant.

D. Other

1. Driver shall be manufactured in a factory certified to ISO 9001 Quality System Standards.
2. Driver shall carry a five-year limited warranty from date of manufacture against defects in material or workmanship, including replacement, for operation at a maximum case temperature of 75C
3. Dimmable drivers shall be controlled by a Class 2 low voltage 0-10VDC controller with dimming range controlled between 1 and 8VDC with source current 150µA.
4. Manufacturer shall have a 10-year history of producing electronic drivers for the North American market.

E. Nominal Operating Voltage: Multi tap drivers will provide **120Vac and/or 277Vac**.

2.4 INTERNAL DOWNLIGHT DRIVER

A. Physical Characteristics

1. Driver shall be available in an all metal-can construction for optimal thermal performance.
2. Driver shall be in a compact enclosure with integrated studs so that it can be mounted on the outside or a junction box, without the need of an additional enclosure.
3. Driver shall be provided with integral color-coded connectors.

B. Performance Requirements

1. Driver shall operate from 50/60 Hz input source of 120V through 277V with sustained variations of +/- 10% (voltage) with no damage to the Driver.
2. Driver output shall be regulated to +/- 5% across published load range.
3. Driver shall have an easy way to lower the output current, without using the dimming leads.
4. Driver shall have a Power Factor greater than 0.90 for primary application to 50% of full load rating.
5. Driver input current shall have Total Harmonic Distortion (THD) of less than 20% to 50% of full load rating.
6. Driver shall have a Class A sound rating.
7. Driver shall have a minimum operating temperature of -20C (-4F).

8. Driver shall tolerate sustained open circuit and short circuit output conditions without fail and auto-resetting without need for external fuses or trip devices.
9. Driver output ripple current shall be less than 15% measured peak-to-average, with ripple frequency >100Hz.
10. Driver performance requirements shall be met when operated to 50% of full load rating.
11. Driver shall be rated for UL Damp and Dry locations.
12. Driver shall have integral common mode and differential mode surge protection of 2.5kV(100kHz 30ohm ring wave).
13. Driver shall have integral thermal foldback to reduce driver power above rated case temperature to protect the driver if temperatures reach unacceptable levels.
14. Driver shall comply with NEMA 410 for in-rush current limits.
15. Driver shall incorporate an integral means of limiting surges to the LEDs.

C. Regulatory

1. Driver shall not contain any Polychlorinated Biphenyl (PCB).
2. Driver shall be Underwriters Laboratories (UL) recognized Class 2 per UL1310 or Canadian Standards Association (CSA) recognized Class 2 per CSA-C22.2.
3. Driver shall comply with applicable requirements of the Federal Communications Commission (FCC) rules and regulations, Title 47 CFR part 15, for Non-Consumer equipment.
4. Driver shall be RoHS compliant.

D. Other

1. Driver shall be manufactured in a factory certified to ISO 9001 Quality System Standards.
2. Driver shall carry a five-year limited warranty from date of manufacture against defects in material or workmanship, including replacement, for operation at a maximum case temperature of 75C.
3. Dimmable drivers shall be controlled by a Class 2 low voltage 0-10VDC controller with dimming range controlled between 1 and 8VDC with source current 150µA.
4. Manufacturer shall have a 10-year history of producing electronic drivers for the North American market.
5. Nominal Operating Voltage: Multi tap drivers will provide **120Vac and/or 277Vac**

2.5 DOWNLIGHT

A. **Luminaires on this project have been prior approved and only those indicated on Luminaire Schedule are allowed to bid this project.**

B. Minimum **1,000** lumens. Minimum allowable efficacy of **80** lumens per watt. Unless noted otherwise on luminaires schedule.

C. Universal mounting bracket.

D. Integral junction box with conduit fittings.

2.6 STRIP LIGHT

A. **Luminaires on this project have been prior approved and only those indicated on Luminaire Schedule are allowed to bid this project.**

B. Minimum **750** lumens. Minimum allowable efficacy of **80** lumens per watt.

C. Integral junction box with conduit fittings.

2.7 MATERIALS

A. Metal Parts:

1. Free of burrs and sharp corners and edges.
2. Sheet metal components shall be steel unless otherwise indicated.
3. Form and support to prevent warping and sagging.

B. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit new LEDs without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during replacement and when secured in operating position.

C. Housings:

1. Will be as called for in the Luminaire Schedule for this project. This will include housing and heat sink.
2. Powder-coat and painted finish. Unless otherwise noted in the luminaire schedule for this project.

D. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Locate labels where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

1. Label shall include the following lamp characteristics:

a. "USE ONLY" and include specific lamp type.
b. Lamp diameter, shape, size, wattage, and coating.
c. CCT and CRI for all luminaires.

2.8 METAL FINISHES

A. Variations in finishes are unacceptable in the same piece. Variations in finishes of adjoining components are acceptable if they are within the range of approved Samples and if they can be and are assembled or installed to minimize contrast.

2.9 LUMINAIRE FIXTURE SUPPORT COMPONENTS

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as luminaire.

C. Wires: ASTM A 641/A 641 M, Class 3, soft temper, zinc-coated steel, **12 gage**.

D. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.

E. Hook Hangers: Integrated assembly matched to luminaire, line voltage, and equipment with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before fixture installation. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 TEMPORARY LIGHTING

A. If approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is sufficiently complete, clean luminaires used for temporary lighting and install new lamps.

3.3 INSTALLATION

A. Comply with NECA 1.

B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

C. Install lamps in each luminaire.

D. Supports:

1. Sized and rated for luminaire weight.
2. Able to maintain luminaire position after cleaning and replacement of LEDs.
3. Provide support for luminaire without causing deflection of ceiling or wall.
4. Luminaire mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and vertical force of 400 percent of luminaire weight.

E. Flush-Mounted Luminaire Support:

1. Secured to outlet box.
2. Attached to ceiling structural members at four points equally spaced around circumference of luminaire.
3. Trim ring flush with finished surface.

F. Wall-Mounted Luminaire Support:

1. **Attached using through bolts and backing plates on either side of wall as means of attachment**.
2. Do not attach luminaires directly to gypsum board.

G. Ceiling-Recessed-Mounted Luminaires:

1. Secure to any required outlet box.
2. Secure luminaire to the luminaire opening using approved fasteners in a minimum of four locations, spaced near corners of luminaire.
3. Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.

H. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

3.4 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
2. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

B. Luminaire will be considered defective if it does not pass operation tests and inspections.

C. Prepare test and inspection reports.

D. Adjusting

E. Occupancy Adjustments: When requested within **12** months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied conditions. Make up to **two** visits to Project during other-than-normal hours for this purpose. Some of this work may be required during hours of darkness.

1. During adjustment visits, inspect all luminaires. Replace drivers or luminaires that are defective.
2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
3. Adjust the aim of luminaires in the presence of the Architect.

END OF SECTION 26 5119

SECTION 26 5219 - EMERGENCY AND EXIT LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Emergency lighting units.
2. Exit signs.
3. Luminaire supports.

1.3 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color Rendering Index.

C. Emergency Lighting Unit: A lighting unit with internal or external emergency battery powered supply and the means for controlling and charging the battery and unit operation.

D. Fixture: See "Luminaire" Paragraph.

E. Lumen: Measured output of lamp and luminaire, or both.

F. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of emergency lighting unit, exit sign, and emergency lighting support.

1. Include data on features, accessories, and finishes.
2. Include physical description of the unit and dimensions.
3. Battery and charger for light units.
4. Include life, output of luminaire (lumens, CCT, and CRI), and energy-efficiency data.
5. Include photometric data and adjustment factors based on laboratory tests, complying with IES LM-45, for each luminaire type.

a. Testing Agency Certified Data: For indicated luminaires and signs, photometric data certified by a qualified independent testing agency. Photometric data for remaining luminaires and signs shall be certified by manufacturer.

b. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.

B. Shop Drawings: For nonstandard or custom luminaires.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Samples: For each product and for each color and texture specified.

D. Samples for Initial Selection: For each type of luminaire with factory-applied finishes.

E. Samples for Verification: For each type of luminaire.

1. Include Samples of luminaires and accessories to verify finish selection.

F. Product Schedule:

1. For emergency lighting units. Use same designations indicated on Drawings.
2. For exit signs. Use same designations indicated on Drawings.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Luminaires.
2. Suspended ceiling components.
3. Partitions and millwork that penetrate the ceiling or extend to within 12 inches of the plane of the luminaires.
4. Structural members to which equipment will be attached.
5. Size and location of initial access modules for acoustical tile.
6. Items penetrating finished ceiling including the following:

a. Other luminaires.
b. Air outlets and inlets.
c. Speakers.
d. Ceiling-mounted projectors.
e. Sprinklers.
f. Access panels.

B. Qualification Data: For testing laboratory providing photometric data for luminaires.

C. Product Certificates: For each type of luminaire.

D. Seismic Qualification Data: For luminaires, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
4. Provide seismic qualification certificate for each piece of equipment.

E. Product Test Reports: For each luminaire for tests performed by a qualified testing agency.

F. Sample Warranty: For manufacturer's special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires and lighting systems to include in emergency, operation, and maintenance manuals.

1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. LED boards: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
2. Luminaire-mounted, emergency battery pack: One for every 20 emergency lighting units. Furnish at least one of each type.
3. Diffusers and Lenses: One for every 100 of each type and rating installed. Furnish at least one of each type.

1.8 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturer's laboratory that is accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.

B. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7, accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products, and complying with the applicable IES testing standards.

C. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

D. Mockups: For interior luminaires in room or module mockups, complete with power and control connections.

1. Obtain Architect's approval of luminaires and signs in mockups before starting installations.
2. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.10 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: Two year(s) from date of Substantial Completion.

B. Special Warranty for Emergency Lighting Batteries: Manufacturer's standard form in which manufacturer of battery-powered emergency lighting unit agrees to repair or replace components of rechargeable batteries that fail in materials or workmanship within specified warranty period.

   1. Warranty Period for Emergency Power Unit Batteries: Five years from date of Substantial Completion. Full warranty shall apply for first year and prorated warranty for the remaining four years.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE/SEI 7. Luminaires and LEDs shall be labeled vibration and shock resistant.

   1. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified and the luminaire will be fully operational during and after the seismic event."

2.2 GENERAL REQUIREMENTS FOR EMERGENCY LIGHTING

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. NRTL Compliance: Fabricate and label emergency lighting units, exit signs, and batteries to comply with UL 924.

C. Comply with NFPA 70 and NFPA 101.

D. Comply with NEMA LE 4 for recessed luminaires.

E. Comply with UL 1598 for fluorescent luminaires.

F. Lamp Base: Comply with ANSI C81.61 or IEC 60061-1.

G. Bulb Shape: Complying with ANSI C79.1.

H. Internal Type Emergency Power Unit: Self-contained, modular, battery-inverter unit, factory mounted within luminaire body and compatible with LED Driver.

1. Emergency Connection: Operate one LED board continuously at an output of 1100 lumens each upon loss of normal power. Connect unswitched circuit to battery-inverter unit and switched circuit to luminaire ballast.
2. Operation: Relay automatically turns lamp on when power-supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
3. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

    a. Ambient Temperature: Less than 0 deg F or exceeding 104 deg F, with an average value exceeding 95 deg F over a 24-hour period.
    b. Ambient Storage Temperature: Not less than minus 4 deg F and not exceeding 140 deg F.
    c. Humidity: More than 95 percent (condensing).
    d. Altitude: Exceeding this project site in feet.

4. Test Push-Button and Indicator Light: Visible and accessible without opening luminaire or entering ceiling space.

    a. Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
    b. Indicator Light: LED indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.

5. Battery: Sealed, maintenance-free, nickel-cadmium type.
6. Charger: Fully automatic, solid-state, constant-current type with sealed power transfer relay.
7. Remote Test: Switch in handheld remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.

8. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

2.3 EXIT SIGNS

A. General Requirements for Exit Signs: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.

B. Internally Lighted Signs:

1. Manufacturers: **Luminaires on this project have been prior approved and only those indicated on Luminaire Schedule are allowed to bid this project.**

2. Operating at nominal voltage of 120 V ac, 277 V ac.
3. Lamps for AC Operation: Fluorescent, two for each luminaire; 20,000 hours of rated lamp life.
4. Lamps for AC Operation: LEDs; 50,000 hours minimum rated lamp life.
5. Self-Powered Exit Signs (Battery Type): Internal emergency power unit.
6. Master/Remote Sign Configurations:

   a. Master Unit: Comply with requirements above for self-powered exit signs, and provide additional capacity in LED power supply for power connection to remote unit.
   b. Remote Unit: Comply with requirements above for self-powered exit signs, except omit power supply, battery, and test features. Arrange to receive full power requirements from master unit. Connect for testing concurrently with master unit as a unified system.

2.4 MATERIALS

A. Metal Parts:

1. Free of burrs and sharp corners and edges.
2. Sheet metal components shall be steel unless otherwise indicated.
3. Form and support to prevent warping and sagging.

B. Doors, Frames, and Other Internal Access:

1. Smooth operating, free of light leakage under operating conditions.
2. Designed to permit relamping without use of tools.
3. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

C. Diffusers and Globes:

1. Diffuse glass.
2. Glass: Annealed crystal glass unless otherwise indicated.

3. Acrylic: 100 percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
4. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.

D. Housings:

1. Extruded aluminum housing and heat sink.
2. Clear anodized finish.

E. Conduit: Electrical metallic tubing, minimum 3/4 inch in diameter.

2.5 METAL FINISHES

A. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

2.6 LUMINAIRE SUPPORT COMPONENTS

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

B. Support Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for conditions affecting performance of luminaires.

B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before luminaire installation.

C. Examine walls, floors, roofs, and ceilings for suitable conditions where emergency lighting luminaires will be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Comply with NECA 1.

B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

C. Install lamps in each luminaire.

D. Supports:

1. Sized and rated for luminaire and emergency power unit weight.
2. Able to maintain luminaire position when testing emergency power unit.
3. Provide support for luminaire and emergency power unit without causing deflection of ceiling or wall.
4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire and emergency power unit weight and vertical force of 400 percent of luminaire weight.

E. Wall-Mounted Luminaire Support:

1. Attached to a minimum 20-gage backing plate attached to wall structural members.
2. Do not attach luminaires directly to gypsum board.

F. Suspended Luminaire Support:

1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
2. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of luminaire oscillations. Support outlet box vertically to building structure using approved devices.
3. Continuous Rows of Luminaires: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of luminaire chassis, including one at each end.
4. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.

G. Ceiling Grid Mounted Luminaires:

1. Secure to any required outlet box.
2. Secure emergency power unit using approved fasteners in a minimum of four locations, spaced near corners of emergency power unit.
3. Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.

3.3 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

B. Luminaire will be considered defective if it does not pass operation tests and inspections.

C. Prepare test and inspection reports.

D. Spare Exit signs:

1. Provide 10% spare exit of the total installed in this facility.
2. These spare units will be utilized and installed per AHJ final inspection of egress paths. Should AHJ request additional exit signs these spare will be installed as directed.
3. Owner will bear no cost for these spare and any installation due to AHJ requirement to add additional exit signs.
4. Any exit signs not used will be given to owner.

3.5 STARTUP SERVICE

A. Perform startup service:

1. Charge emergency power units and batteries minimum of 24 hours and conduct one-hour discharge test.

3.6 ADJUSTING

A. Adjustments: Within 12 months of date of Substantial Completion, provide on-site visit to do the following:

1. Inspect all luminaires. Replace lamps, emergency power units, batteries, signs, or luminaires that are defective.

    a. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

2. Conduct short-duration tests on all emergency lighting.

END OF SECTION 26 5219

SECTION 26 5619 – LED EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Exterior solid-state luminaires that are designed for and exclusively use LED lamp technology.
2. Luminaire supports.
3. Luminaire-mounted photoelectric relays.

B. Related Requirements:

Division 26, Section 26 5119, LED Interior Lighting, for interior Luminaires, and accessories.

1.3 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color rendering index.

C. Luminaire: See "Luminaire."

D. IP: International Protection or Ingress Protection Rating.

E. Lumen: Measured output of lamp and luminaire, or both.

F. Luminaire: Complete lighting unit, including LEDs, Drivers, Reflector, and Housing.

1.4 ACTION SUBMITTALS

A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections

B. Product Data: For each type of luminaire.

1. Arrange in order of luminaire schedule designation.
2. Include data on features, accessories, and finishes.
3. Include physical description and dimensions of luminaire.
4. LEDs, include life, output (lumens, CCT, and CRI), and energy-efficiency data.

5. Photometric data and adjustment factors based on laboratory tests, complying with IES Lighting Measurements Testing and Calculation Guides, of each luminaire type. The adjustment factors shall be for LEDs and accessories identical to those indicated for the luminaire as applied in this Project; IES LM-79 and IES LM-80

    a. Manufacturer's Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the NVLAP for Energy Efficient Lighting Products.
    b. Testing Agency Certified Data: For indicated luminaires, photometric data certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.

6. Wiring diagrams for power, control, and signal wiring. Wiring diagrams for control system showing both factory-installed and field-installed wiring for specific system of this Project, and differentiating between factory-installed and field-installed wiring.
7. Photoelectric relays.
8. Means of attaching luminaires to supports and indication that the attachment is suitable for components involved.
9. Luminaire, LEDs, Drivers, Poles, and accessories. Include data on features, Poles, accessories, finishes, and the following:

    a. Outline drawings indicating dimensions and principal features of Luminaire and Poles.
    b. Electrical Ratings and Photometric Data: Certified results of independent laboratory tests for Luminaires and LEDs.

10. Wind Resistance Calculations: Certified by a registered professional engineer
11. Anchor-Bolt Templates: Keyed to specific poles and certified by manufacturer.
12. Field test reports indicating and interpreting test results specified in Part 3 of this section.
13. Maintenance data for products to include in the operation and maintenance manual specified in Division 1.
14. Product certificates signed by manufacturers of lighting units certifying that their products comply with specified requirements.

C. Include lighting calculations for each space using the following reflectance's, 75,45,20, and working plane height of 30" AFF for comparison to Basis of Design

D. Shop Drawings: For nonstandard or custom luminaires.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, and required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

E. Samples: For each luminaire and for each color and texture indicated with factory-applied finish.

F. Delegated-Design Submittal: For luminaire supports.

1. Include design calculations for luminaire supports and seismic restraints.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Luminaires.
2. Structural members to which luminaires will be attached.
3. Underground utilities and structures.
4. Existing underground utilities and structures.
5. Above-grade utilities and structures.
6. Existing above-grade utilities and structures.
7. Building features.
8. Vertical and horizontal information.

B. Qualification Data: For testing laboratory providing photometric data for luminaires.

C. Seismic Qualification Data: For luminaires, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Product Certificates: For each type of the following:

1. Luminaire.
2. Photoelectric relay.

E. Product Test Reports: For each luminaire, for tests performed by manufacturer and witnessed by a qualified testing agency.

F. Source quality-control reports.

G. Sample warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires to include in operation and maintenance manuals.

1. Provide a list of all LED types used on Project. Use ANSI and manufacturers' codes.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. LEDs: One for every 50 of each type and rating installed. Furnish at least one of each type.
2. Glass, Acrylic, and Plastic Lenses, Covers, and Other Optical Parts: One for every 100 of each type and rating installed. Furnish at least one of each type.
3. Diffusers and Lenses: One for every 50 of each type and rating installed. Furnish at least one of each type.
4. Globes and Guards: One for every 50 of each type and rating installed. Furnish at least one of each type.

1.8 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturers' laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.

B. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7, accredited under the NVLAP for Energy Efficient Lighting Products and complying with applicable IES testing standards.

C. Provide luminaires from a single manufacturer for each luminaire type.

D. Listing and Labeling: Provide Luminaires and accessories specified in this Section that are listed and labeled for their indicated use and installation conditions on Project.

1. Special Listing and Labeling: Provide Luminaires for use underwater that are specifically listed and labeled for such use. Provide Luminaires for use in hazardous (classified) locations that are listed and labeled for the specific hazard.
2. The Terms "Listed" and "Labeled": As defined in the National Electrical Code, Article 100.
3. Electrical Component Standard: Provide components that comply with NFPA 70 and that are listed and labeled by UL where available.

E. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

F. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

G. Mockups: For exterior luminaires, complete with power and control connections.

1. Obtain Architect's approval of luminaires in mockups before starting installations.
2. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed work.
3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.9 DELIVERY, STORAGE, AND HANDLING

A. General: Store poles on decay-resistant treated skids at least 12 inches above grade and vegetation. Support pole to prevent distortion and arrange to provide free air circulation

B. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering prior to shipping.

C. Metal Poles: Retain factory-applied pole wrappings until just before pole installation. For poles with nonmetallic finishes, handle with web fabric straps

1.10 FIELD CONDITIONS

A. Verify existing and proposed utility structures prior to the start of work associated with luminaire installation.

B. Mark locations of exterior luminaires for approval by Architect prior to the start of luminaire installation.

1.11 WARRANTY

A. General Warranty: The warranty specified in this Article shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by the Contractor under requirements of the Contract Documents

B. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Structural failures, including luminaire support components.
b. Faulty operation of luminaires and accessories.
c. Deterioration of metals, metal finishes, and other materials beyond normal weathering. Warranty against perforation or erosion of finish due to weathering.
d. Color Retention: Warranty against fading, staining, and chalking due to effects of weather and solar radiation

2. Warranty Period: 5 year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Products: Luminaires on this project have been prior approved and only those indicated on Luminaire Schedule are allowed to bid this project.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to SCE/SEI 7.

B. Seismic Performance: Luminaires and LEDs shall be labeled vibration and shock resistant.

1. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified and the luminaire will be fully operational during and after the seismic event."

2.3 LUMINAIRE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. NRTL Compliance: Luminaires shall be listed and labeled for indicated class and division of hazard by an NRTL.

C. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

D. UL Compliance: Comply with UL 1598 and listed for wet location where indicated in Luminaire schedule.

E. Bulb shape complying with ANSI C79.1.

F. CRI of minimum 80.

G. CCT of 4100 K or as indicated in the luminaire schedule.

H. L70 LED life of 50,000 minimum hours.

I. Internal driver.

J. Nominal Operating Voltage: Multi-Tap Drivers - 120 V or 277 V.

K. In-line Fusing: Separate in-line fuse for each luminaire.

L. LED Rating: LED marked for outdoor use.

M. Source Limitations: Obtain luminaires from single source from a single manufacturer.

N. Source Limitations: For luminaires, obtain each color, grade, finish, type, and variety of luminaire from single source with resources to provide products of consistent quality in appearance and physical properties.

O. Housings: Rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use. Provide filter/breather for enclosed Luminaires.

P. Exposed Hardware Material: Stainless steel.

Q. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

R. Lenses and Refractors: Materials as indicated. Use heat- and aging-resistant, resilient gaskets to seal and cushion lens and refractor mounting in Luminaire doors.

2.4 MATERIALS

A. Metal Parts: Free of burrs and sharp corners and edges.

B. Sheet Metal Components: Stainless steel. Form and support to prevent warping and sagging.

C. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit re-lamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during re-lamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses.

D. Diffusers and Globes:

1. Acrylic Diffusers: 100 percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
2. Glass: Annealed crystal glass unless otherwise indicated.
3. Lens Thickness: At least 0.125 inch (3.175 mm) minimum unless otherwise indicated.

E. Lens and Refractor Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.

F. Reflecting surfaces shall have minimum reflectance as follows unless otherwise indicated:

1. White Surfaces: 85 percent.
2. Specular Surfaces: 83 percent.
3. Diffusing Specular Surfaces: 75 percent.

G. Housings:

1. Rigidly formed, weather- and light-tight enclosure that will not warp, sag, or deform in use.
2. Provide filter/breather for enclosed luminaires.

H. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

1. Label shall include the following lamp characteristics:

a. "USE ONLY" and include specific lamp type.
b. Lamp diameter, shape, size, wattage and coating.
c. CCT and CRI for all luminaires.

2.5 FINISHES

A. Variations in Finishes: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are not acceptable. Arm, Bracket, and Tenon Mount will match poles' finish.

B. Factory-Applied Finish for Steel Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1 or SSPC-SP 8.
2. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.

a. Color: As selected by Architect from manufacturer's full range.

C. Mountings, Fastenings, and Appurtenances: Corrosion-resistant items compatible with support components. Use materials that will not cause galvanic action at contact points. Use mountings that correctly position luminaire to provide indicated light distribution.

2.6 LUMINAIRE SUPPORT COMPONENTS

A. Comply with requirements in Section 26 0529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

B. Pole-Mounted Luminaires: Conform to AASHTO LTS-3.

C. Wind-load strength of total support assembly, including pole, arms, appurtenances, base, and anchorage, is adequate to carry itself plus Luminaires indicated at indicated heights above grade without failure, permanent deflection, or whipping in steady winds of 100 Mi./Hr. with a gust factor of 1.3.

D. Poles: Provide factory installed vibration dampers.

E. Pole Shafts: Round, straight.

F. Pole Bases: Anchor type with galvanized steel hold-down or anchor bolts, leveling nuts, and bolt covers.

G. Poles: Steel tubing conforming to ASTM A 500, Grade B, carbon steel with a minimum yield of 46,000 psi. Poles are 1-piece construction up to 40 feet in length and have access handhole in wall.

H. Metal Pole Grounding Provisions: Welded 1/2-inch threaded lug, accessible through handhole.

I. Steel Mast Arms: Fabricated from 2-inch NPS (DN50) black steel pipe, continuously welded to pole attachment plate with span and rise as indicated.

J. Metal Pole Brackets: Designed to match pole metal. Provide cantilever brackets without underbrace, in sizes and styles indicated, with straight tubular end section to accommodate Luminaire.

K. Pole-Top Tenons: Fabricated to support Luminaire or Luminaires and brackets indicated and securely fastened to pole top.

L. Concrete for Pole Foundations: Comply with structural details for the base required for Poles on this project. Details in this division drawings indicate electrical information and do not call out any structural information.

1. Construct according to Division 3, Section 03 3000, Cast-in-Place Concrete.
2. Comply with details and manufacturer's recommendations for reinforcing, anchor bolts, nuts, and washers. Verify anchor-bolt templates by comparing with actual pole bases furnished.
3. Finish: Trowel and rub smooth parts exposed to view

M. Embedded Poles: Set poles to indicated depth, but not less than 1/6 of pole length below finish grade. Dig holes large enough to permit use of tampers the full depth of hole. Backfill in 6-inch layers and thoroughly tamp each layer so compaction of backfill is equal to or greater than that of undisturbed earth.

N. Pole Installation: Use web fabric slings (not chain or cable) to raise and set poles.

O. Luminaire Attachment: Fasten to indicated structural supports.

P. Luminaire Attachment with Adjustable Features or Aiming: Attach fixtures and supports to allow aiming for indicated light distribution.

Q. Provide LED Luminaires with indicated LEDs according to manufacturer's written instructions. Replace malfunctioning LEDs.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for luminaire electrical conduit to verify actual locations of conduit connections before luminaire installation.

C. Examine walls, roofs, and overhang ceilings for suitable conditions where luminaires will be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 TEMPORARY LIGHTING

A. If approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is substantially complete, clean luminaires used for temporary lighting and install new lamps.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Comply with NECA 1.

B. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.

C. Install lamps in each luminaire.

D. Fasten luminaire to structural support.

1. Sized and rated for luminaire weight.
2. Able to maintain luminaire position after cleaning and relamping.
3. Support luminaires without causing deflection of finished surface.
4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and a vertical force of 400 percent of luminaire weight.

E. Wall-Mounted Luminaire Support:

1. Attached using through bolts and backing plates on either side of wall.

F. Wiring Method: Install cables in raceways. Conceal raceways and cables.

G. Set Luminaires securely according to manufacturer's written instructions and approved Shop Drawings. Install luminaires level, plumb, and square with finished grade unless otherwise indicated. Install luminaires at height and aiming angle as indicated on Drawings.

H. Coordinate layout and installation of luminaires with other construction.

I. Luminaire Attachment with Adjustable Features or Aiming: Attach fixtures and supports to allow aiming for indicated light distribution. Adjust luminaires that require field adjustment or aiming once luminaire is in place .

J. Comply with requirements in Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables" and Section 26 0533 "Raceways and Boxes for Electrical Systems" for wiring connections and wiring methods.

K. Provide LED Luminaires with indicated LEDs according to manufacturer's written instructions. Replace malfunctioning LEDs

3.4 GROUNDING

A. Ground fixtures and metal poles according to Division 26, Section 26 0526, Grounding and Bonding for Electrical Systems.

1. Poles: Install 10-foot driven ground rod at each pole.
2. Nonmetallic Poles: Ground metallic components of lighting unit and foundations. Connect fixtures to grounding system with No. 6 AWG conductor, minimum

3.5 CORROSION PREVENTION

A. Steel Conduits: Comply with Section 26 0533 "Raceways and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch- (0.254-mm-) thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.6 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."

3.7 FIELD QUALITY CONTROL

A. Inspect each installed luminaire for damage. Replace damaged luminaires and components.

B. Give advance notice of dates and times for field tests.

C. Provide instruments to make and record test results. Use photometers with calibration referenced to National Institute of Standards and Technology (NIST) standards.

D. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Operational Test: After installing luminaires, control system, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
2. Verify operation of photoelectric controls.
3. Check for intensity of illumination.
4. Check for uniformity of illumination.
5. Check for excessively noisy Driver.

E. Illumination Tests:

1. Measure light intensities at night. Use photometers with calibration referenced to NIST standards. Comply with the following IES testing guide(s):

    a. IES LM-5.
    b. IES LM-50.
    c. IES LM-52.
    d. IES LM-64.
    e. IES LM-72.

F. Luminaire will be considered defective if it does not pass tests and inspections. Replace or repair damaged and malfunctioning units, make necessary adjustments, and retest. Repeat procedure until all units operate properly

G. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain luminaires.

3.9 ADJUSTING

A. Clean units after installation. Use methods and materials recommended by manufacturer. Adjust aimable fixtures to provide required light intensities.

B. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied conditions. Make up to two visits to Project during other-than-normal hours for this purpose. Some of this work may be required during hours of darkness.

1. During adjustment visits, inspect all luminaires. Replace LEDs or luminaires that are defective.
2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
3. Adjust the aim of luminaires in the presence of the Architect.

3.10 EXTERIOR LIGHTING FIXTURE SCHEDULE

A. The luminaire schedule located in the construction drawings describes each type of luminaire for the project. Manufacturer’s catalog numbers are given for convenience. Where discrepancies occur between catalog numbers and the descriptive information, the descriptive information shall take precedence. Some required features, options, accessory equipment or special order requirements may not be included in the catalog number.

3.11 SPARE MATERIAL

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents. All extra material will be delivered to the location as directed by the district. Provide TWO spare luminaires of each type.

B. LED: Five for every 100 of each type and rating installed for each type of luminaire. Furnish at least one of each type in every instance.

C. Diffusers and Lenses: Five for every 100 of each type and rating installed for each type of luminaire. Furnish at least one of each type in every instance.

D. LED Drivers: Five for every 100 of each type and rating installed. Furnish at least one of each type.

END OF SECTION 26 5619

SECTION 270526 - GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Grounding conductors.
2. Grounding connectors.
3. Grounding busbars.
4. Grounding rods.
5. Grounding labeling.

1.3 DEFINITIONS

A. BCT: Bonding conductor for telecommunications.

B. TGB: Telecommunications grounding busbar.

C. TMGB: Telecommunications main grounding busbar.

D. Service Provider: The operator of a service that provides telecommunications transmission delivered over access provider facilities.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For communications equipment room signal reference grid. Include plans, elevations, sections, details, and attachments to other work.

1.5 INFORMATIONAL SUBMITTALS

A. As-Built Data: Plans showing as-built locations of grounding and bonding infrastructure, including the following:

1. Ground rods.
2. Ground and roof rings.
3. BCT, TMGB, TGBs, and routing of their bonding conductors.

B. Qualification Data: For testing agency and testing agency's field supervisor.

C. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

1. Installation Supervision: Installation shall be under the direct supervision of New Mexico ES3J, who shall be present at all times when Work of this Section is performed at Project site.
2. Field Inspector: Currently registered by BICSI as a designer RCDD to perform the on-site inspection.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with UL 467 for grounding and bonding materials and equipment.

C. Comply with TIA-607-B.

2.2 CONDUCTORS

A. Comply with UL 486A-486B.

B. Insulated Conductors: Stranded copper wire, green or green with yellow stripe insulation, insulated for 600 V, and complying with UL 83.

1. Ground wire for custom-length equipment ground jumpers shall be No. 6 AWG, 19-strand, UL-listed, Type THHN wire.
2. Cable Tray Equipment Grounding Wire: No. 8 AWG.

C. Cable Tray Grounding Jumper:
1. Not smaller than No. 10 AWG and not longer than 12 inches (300 mm). If jumper is a wire, it shall have a crimped grounding lug with one hole and standard barrel for one crimp. If jumper is a flexible braid, it shall have a one- or two-hole ferrule. Attach with grounding screw or connector provided by cable tray manufacturer.

D. Bare Copper Conductors:

1. Solid Conductors: ASTM B3.
2. Stranded Conductors: ASTM B8.
3. Tinned Conductors: ASTM B33.
4. Bonding Cable: 28 kcmils (14.2 sq. mm), 14 strands of No. 17 AWG conductor, and 1/4 inch (6.3 mm) in diameter.
5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
6. Bonding Jumper: Tinned-copper tape, braided conductors terminated with two-hole copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.

2.3 CONNECTORS

A. Irreversible connectors listed for the purpose. Listed by an NRTL as complying with NFPA 70 for specific types, sizes, and combinations of conductors and other items connected. Comply with UL 486A-486B.

B. Compression Wire Connectors: Crimp-and-compress connectors that bond to the conductor when the connector is compressed around the conductor. Comply with UL 467.

1. Electroplated tinned copper, C and H shaped.

C. Busbar Connectors: Cast silicon bronze, solderless compression-type, mechanical connector; with a long barrel and two holes spaced on 5/8- or 1-inch (15.8- or 25.4-mm) centers for a two-bolt connection to the busbar.

2.4 GROUNDING BUSBARS

A. TMGB: Predrilled, wall-mounted, rectangular bars of hard-drawn solid copper, **1/4 by 4 inches (6.3 by 100 mm)** in cross section, length as indicated on Drawings. The busbar shall be NRTL listed for use as TMGB and shall comply with TIA-607-B.

1. Predrilling shall be with holes for use with lugs specified in this Section.
2. Mounting Hardware: Stand-off brackets that provide a **4-inch (100-mm)** clearance to access the rear of the busbar. Brackets and bolts shall be stainless steel.
3. Stand-off insulators for mounting shall be Lexan or PVC. Comply with UL 891 for use in 600-V switchboards, impulse tested at 5000 V.

B. TGB: Predrilled rectangular bars of hard-drawn solid copper, **1/4 by 2 inches (6.3 by 50 mm)** in cross section, length as indicated on Drawings. The busbar shall be for wall mounting, shall be NRTL listed as complying with UL 467, and shall comply with TIA-607-B.

1. Predrilling shall be with holes for use with lugs specified in this Section.
2. Mounting Hardware: Stand-off brackets that provide at least a 2-inch (50-mm) clearance to access the rear of the busbar. Brackets and bolts shall be stainless steel.
3. Stand-off insulators for mounting shall be Lexan or PVC. Comply with UL 891 for use in 600-V switchboards, impulse tested at 5000 V.

C. Rack and Cabinet Grounding Busbars: Rectangular bars of hard-drawn solid copper, accepting conductors ranging from No. 14 to No. 2/0 AWG, NRTL listed as complying with UL 467, and complying with TIA-607-B. Predrilling shall be with holes for use with lugs specified in this Section.

1. Cabinet-Mounted Busbar: Terminal block, with stainless-steel or copper-plated hardware for attachment to the cabinet.
2. Rack-Mounted Horizontal Busbar: Designed for mounting in 19- or 23-inch (483- or 584-mm) equipment racks. Include a copper splice bar for transitioning to an adjoining rack, and stainless-steel or copper-plated hardware for attachment to the rack.

2.5 IDENTIFICATION

A. Comply with requirements for identification products in Section 270553 "Identification for Communications Systems."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the ac grounding electrode system and equipment grounding for compliance with requirements for maximum ground-resistance level and other conditions affecting performance of grounding and bonding of the electrical system.

B. Inspect the test results of the ac grounding system measured at the point of BCT connection.

C. Proceed with connection of the BCT only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Bonding shall include the ac utility power service entrance, the communications cable entrance, and the grounding electrode system. The bonding of these elements shall form a loop so that each element is connected to at least two others.

B. Comply with NECA 1.

C. Comply with TIA-607-B.

3.3 APPLICATION

A. Conductors: Install solid conductor for No. 8 AWG and smaller and stranded conductors for No. 6 AWG and larger unless otherwise indicated.

1. The bonding conductors between the TGB and structural steel of steel-frame buildings shall not be smaller than No. 6 AWG.
2. The bonding conductors between the TMGB and structural steel of steel-frame buildings shall not be smaller than No. 6 AWG.

B. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

C. Conductor Support:

1. Secure grounding and bonding conductors at intervals of not less than 36 inches (900 mm).

D. Grounding and Bonding Conductors:

1. Install in the straightest and shortest route between the origination and termination point, and no longer than required. The bend radius shall not be smaller than eight times the diameter of the conductor. No one bend may exceed 90 degrees.
2. Install without splices.
3. Support at not more than 36-inch (900-mm) intervals.
4. Install grounding and bonding conductors in 3/4-inch (21-mm) PVC conduit until conduit enters a telecommunications room. The grounding and bonding conductor pathway through a plenum shall be in EMT. Conductors shall not be installed in EMT unless otherwise indicated.

    a. If a grounding and bonding conductor is installed in ferrous metallic conduit, bond the conductor to the conduit using a grounding bushing that complies with requirements in Section 270528 "Pathways for Communications Systems," and bond both ends of the conduit to a TGB.

3.4 GROUNDING ELECTRODE SYSTEM

A. The BCT between the TMGB and the ac service equipment ground shall not be smaller than No. 1/0 AWG.

3.5 GROUNDING BUSBARS

A. Indicate locations of grounding busbars on Drawings. Install busbars horizontally, on insulated spacers 2 inches (50 mm) minimum from wall, 12 inches (300 mm) above finished floor unless otherwise indicated.

3.6 CONNECTIONS

A. Bond metallic equipment in a telecommunications equipment room to the grounding busbar in that room, using equipment grounding conductors not smaller than No. 6 AWG.

B. Stacking of conductors under a single bolt is not permitted when connecting to busbars.

C. Assemble the wire connector to the conductor, complying with manufacturer's written instructions and as follows:

1. Use crimping tool and the die specific to the connector.
2. Pretwist the conductor.
3. Apply an antioxidant compound to all bolted and compression connections.

D. Primary Protector: Bond to the TMGB with insulated bonding conductor.

E. Structural Steel: Where the structural steel of a steel frame building is readily accessible within the room or space, bond each TGB and TMGB to the vertical steel of the building frame.

F. Electrical Power Panelboards: Where an electrical panelboard for telecommunications equipment is located in the same room or space, bond each TGB to the ground bar of the panelboard.

G. Shielded Cable: Bond the shield of shielded cable to the TGB in communications rooms and spaces. Comply with TIA-568-C.1 and TIA-568-C.2 when grounding shielded balanced twisted-pair cables.

H. Rack- and Cabinet-Mounted Equipment: Bond powered equipment chassis to the cabinet or rack grounding bar. Power connection shall comply with NFPA 70; the equipment grounding conductor in the power cord of cord- and plug-connected equipment shall be considered as a supplement to bonding requirements in this Section.

3.7 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

A. Duct-Bank Grounding Conductor: Bury 12 inches (300 mm) above duct bank when indicated as part of duct-bank installation.

B. Comply with IEEE C2 grounding requirements.

C. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches (100 mm) extends above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches (50 mm) above to 6 inches (150 mm) below concrete. Seal floor opening with waterproof, nonshrink grout.

D. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect grounding conductors to cable armor and cable shields according to written instructions by manufacturer of splicing and termination kits.

3.8 IDENTIFICATION

A. Labels shall be preprinted or computer-printed type.

1. Label TMGB(s) with "fs-TMGB," where "fs" is the telecommunications space identifier for the space containing the TMGB.
2. Label TGB(s) with "fs-TGB," where "fs" is the telecommunications space identifier for the space containing the TGB.
3. Label the BCT and each telecommunications backbone conductor at its attachment point: "WARNING! TELECOMMUNICATIONS BONDING CONDUCTOR. DO NOT REMOVE OR DISCONNECT!"

3.9 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
2. Test the bonding connections of the system using an ac earth ground-resistance tester, taking two-point bonding measurements in each telecommunications equipment room containing a TMGB and a TGB and using the process recommended by BICSI TDMM. Conduct tests with the facility in operation.

    a. Measure the resistance between the busbar and the nearest available grounding electrode. The maximum acceptable value of this bonding resistance is 100 milliohms.

3. Test for ground loop currents using a digital clamp-on ammeter, with a full-scale of not more than 10 A, displaying current in increments of 0.01 A at an accuracy of plus/minus 2.0 percent.

    a. With the grounding infrastructure completed and the communications system electronics operating, measure the current in every conductor connected to the TMGB Maximum acceptable ac current level is 1 A.

C. Grounding system will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

END OF SECTION 270526

SECTION 270528 - PATHWAYS FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Metal conduits and fittings.
2. Nonmetallic conduits and fittings.
3. Optical-fiber-cable pathways and fittings.
4. Metal wireways and auxiliary gutters.
5. Nonmetallic wireways and auxiliary gutters.
6. Metallic surface pathways.
7. Nonmetallic surface pathways.
8. Tele-power poles.
9. Hooks.
10. Boxes, enclosures, and cabinets.
11. Polymer-concrete handholes and boxes for exterior underground cabling.
12. Fiberglass handholes and boxes for exterior underground cabling.

1.3 DEFINITIONS

A. ARC: Aluminum rigid conduit.

B. GRC: Galvanized rigid conduit.

C. IMC: Intermediate metal conduit.

D. RTRC: Reinforced thermosetting resin conduit.

1.4 ACTION SUBMITTALS

A. Product data for the following:

1. Surface pathways
2. Wireways and fittings.
3. Tele-power poles.
4. Boxes, enclosures, and cabinets.
5. Underground handholes and boxes.

PART 2 - PRODUCTS

2.1 METAL CONDUITS AND FITTINGS

A. Description: Metal raceway of circular cross section with manufacturer-fabricated fittings.

B. General Requirements for Metal Conduits and Fittings:

1. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.
2. Comply with TIA-569-D.

C. GRC: Comply with ANSI C80.1 and UL 6.

D. ARC: Comply with ANSI C80.5 and UL 6A.

E. IMC: Comply with ANSI C80.6 and UL 1242.

F. PVC-Coated Steel Conduit: PVC-coated [**GRC**] [**IMC**].

1. Comply with NEMA RN 1.
2. Coating Thickness: 0.040 inch (1 mm), minimum.

G. EMT: Comply with ANSI C80.3 and UL 797.

H. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.
1. Fittings for EMT:

a. Material: Steel
b. Type: Set screw or compression.

2. Expansion Fittings: PVC or steel to match conduit type, complying with UL-467, rated for environmental conditions where installed, and including flexible external bonding jumper.
3. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch (1 mm), with overlapping sleeves protecting threaded joints.

2.2 NONMETALLIC CONDUITS AND FITTINGS

A. Description: Nonmetallic raceway of circular section with manufacturer-fabricated fittings.

B. General Requirements for Nonmetallic Conduits and Fittings:

1. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
2. Comply with TIA-569-D.

C. RNC: Type EPC-80-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.

D. Fittings: Comply with NEMA TC 3; match to conduit or tubing type and material.

E. Solvents and Adhesives: As recommended by conduit manufacturer.

2.3 HOOKS

A. Description: Prefabricated sheet metal cable supports for telecommunications cable.

B. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

C. Comply with TIA-569-D.

D. Galvanized.

E. J shape.

2.4 BOXES, ENCLOSURES, AND CABINETS

A. Description: Enclosures for communications.

B. General Requirements for Boxes, Enclosures, and Cabinets:

1. Comply with TIA-569-D.
2. Boxes, enclosures, and cabinets installed in wet locations shall be listed and labeled as defined in NFPA 70, by an NRTL, and marked for use in wet locations.
3. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
4. Device Box Dimensions: **4 inches square by 2-1/8 inches deep (100 mm square by 60 mm deep)**.
5. Gangable boxes are prohibited.

C. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 3R, with continuous-hinge cover with flush latch unless otherwise indicated.

1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
2. Nonmetallic Enclosures:

    a. Material: Plastic.

3. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

PART 3 - EXECUTION

3.1 PATHWAY APPLICATION

A. Outdoors: Apply pathway products as specified below unless otherwise indicated:

1. Exposed Conduit: GRC
2. Concealed Conduit, Aboveground: EMT.
3. Underground Conduit: RNC, Type EPC-80-PVC.
4. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.

B. Indoors: Apply pathway products as specified below unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage: EMT.
2. Exposed and Subject to Severe Physical Damage: GRC. Pathway locations include the following:

   a. Loading dock.
   b. Mechanical rooms.
   c. Gymnasiums

3. Concealed in Ceilings and Interior Walls and Partitions: EMT
4. Damp or Wet Locations: IMC.
5. Pathways for Optical-Fiber or Communications Cable in Spaces Used for Environmental Air: J-hook
6. Pathways for Concealed General-Purpose Distribution of Optical-Fiber or Communications Cable: EMT>.
7. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel units in institutional and commercial kitchens and damp or wet locations.

C. Minimum Pathway Size: 3/4-inch (21-mm) trade size for copper and aluminum cables, and 1 inch (25 mm) for optical-fiber cables.

D. Pathway Fittings: Compatible with pathways and suitable for use and location.

1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
3. EMT: Use set-screw or compression fittings. Comply with NEMA FB 2.10.

E. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.

3.2 INSTALLATION

A. Comply with the following standards for installation requirements except where requirements on Drawings or in this Section are stricter:

1. NECA 1.
2. NECA/BICSI 568.
3. TIA-569-D.

B. Comply with NFPA 70 limitations for types of pathways allowed in specific occupancies and number of floors.

C. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.

D. Comply with requirements in Section 270529 "Hangers and Supports for Communications Systems" for hangers and supports.

E. Comply with requirements in Section 270544 "Sleeves and Sleeve Seals for Communications Pathways and Cabling" for sleeves and sleeve seals for communications.

F. Keep pathways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal pathway runs above water and steam piping.

G. Complete pathway installation before starting conductor installation.

H. Arrange stub-ups so curved portions of bends are not visible above finished slab.

I. Conceal rigid conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.

J. Support conduit within 12 inches (300 mm) of enclosures to which attached.

K. Stub-ups to Above Recessed Ceilings:

1. Use EMT for pathways.
2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.

L. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install insulated bushings on conduits terminated with locknuts.

M. Install pathways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus one additional quarter-turn.

N. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure, to assure a continuous ground path.

O. Cut conduit perpendicular to the length. For conduits of 2-inch (50-mm) trade size and larger, use roll cutter or a guide to ensure cut is straight and perpendicular to the length.

P. Install pull wires in empty pathways. Use polypropylene or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of pull wire. Secure pull wire, so it cannot fall into conduit. Cap pathways designated as spare alongside pathways in use.

Q. Install devices to seal pathway interiors at accessible locations. Locate seals, so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all pathways at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where an underground service pathway enters a building or structure.
3. Where otherwise required by NFPA 70.

R. Comply with manufacturer's written instructions for solvent welding PVC conduit and fittings.

S. J-Hooks:

1. Size to allow a minimum of 25 percent future capacity without exceeding design capacity limits.
2. Shall be supported by dedicated support wires. Do not use ceiling grid support wire or support rods.
3. Hook spacing shall allow no more than 6 inches (150 mm) of slack. The lowest point of the cables shall be no less than 6 inches (150 mm) adjacent to ceilings, mechanical ductwork and fittings, luminaires, power conduits, power and telecommunications outlets, and other electrical and communications equipment.
4. Space hooks no more than 5 feet (1.5 m) o.c.
5. Provide a hook at each change in direction.

T. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surface to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.

U. Horizontally separate boxes mounted on opposite sides of walls, so they are not in the same vertical channel.

V. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.

W. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

X. Set metal floor boxes level and flush with finished floor surface.

Y. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.3 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:

1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Section 312000 "Earth Moving" for pipe of less than 6 inches (150 mm) in nominal diameter.
2. Install backfill as specified in Section 312000 "Earth Moving."
3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches (300 mm) of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Section 312000 "Earth Moving."
4. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through floor.

a. For stub-ups at equipment mounted on outdoor concrete bases and where conduits penetrate building foundations, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of foundation or equipment base. Install insulated grounding bushings on terminations at equipment.

5. Underground Warning Tape: Comply with requirements in Section 270553 "Identification for Communications Systems."

3.4 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR COMMUNICATIONS PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 270544 "Sleeves and Sleeve Seals for Communications Pathways and Cabling."

3.5 FIRESTOPPING

A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.6 PROTECTION

A. Protect coatings, finishes, and cabinets from damage or deterioration.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 270528

SECTION 270553 - IDENTIFICATION FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Color and legend requirements for labels and signs.
2. Labels.
3. Bands and tubes.
4. Tapes.
5. Signs.
6. Cable ties.
7. Fasteners for labels and signs.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for communications identification products.

B. Identification Schedule:

1. Outlets: Scaled drawings indicating location and proposed designation.
2. Backbone Cabling: Riser diagram showing each communications room, backbone cable, and proposed backbone cable designation.
3. Racks: Scaled drawings indicating location and proposed designation.
4. Patch Panels: Enlarged scaled drawings showing rack row, number, and proposed designations.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Comply with NFPA 70 and TIA 606-B.

B. Comply with ANSI Z535.4 for safety signs and labels.

C. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

2.2 COLOR AND LEGEND REQUIREMENTS

A. Equipment Identification Labels:

1. Black letters on a white field.

2.3 LABELS

A. Self-Adhesive Labels: Vinyl, thermal, transfer-printed, 3-mil- (0.08-mm-) thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.
1. Minimum Nominal Size:

a. 1-1/2 by 6 inches (37 by 150 mm) for raceway and conductors.
b. 3-1/2 by 5 inches (76 by 127 mm) for equipment.
c. As required by authorities having jurisdiction.

2.4 BANDS AND TUBES

A. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inches (50 mm) long, with diameters sized to suit diameters of raceway or cable they identify, that stay in place by gripping action.

2.5 UNDERGROUND-LINE WARNING TAPE

A. Tape:

1. Recommended by manufacturer for the method of installation and suitable to identify and locate underground communications utility lines.
2. Printing on tape shall be permanent and shall not be damaged by burial operations.
3. Tape material and ink shall be chemically inert and not subject to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.

B. Color and Printing:

1. Comply with ANSI Z535.1, ANSI Z535.2, ANSI Z535.3, and ANSI Z535.4.
2. Inscriptions for Orange-Colored Tapes: "TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL-FIBER CABLE" .

2.6 CABLE TIES

A. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, and self-locking.

1. Minimum Width: 3/16 inch (5 mm).

2. Tensile Strength at 73 deg F (23 deg C) according to ASTM D638: 7000 psi (48.2 MPa).
3. UL 94 Flame Rating: 94V-0.
4. Temperature Range: Minus 50 to plus 284 deg F (Minus 46 to plus 140 deg C).
5. Color: Black.

2.7 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 PREPARATION

A. Self-Adhesive Identification Products: Before applying communications identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

3.2 INSTALLATION

A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.

B. Install identifying devices before installing acoustical ceilings and similar concealment.

C. Verify identity of each item before installing identification products.

D. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.

E. Apply identification devices to surfaces that require finish after completing finish work.

F. Install signs with approved legend to facilitate proper identification, operation, and maintenance of communications systems and connected items.

G. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from the floor.

H. Self-Adhesive Labels:

1. On each item, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual.

2. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high label; where two lines of text are required, use labels 2 inches (50 mm) high.

I. Underground-Line Warning Tape:

1. During backfilling of trenches, install continuous underground-line warning tape directly above cable or raceway at 6 to 8 inches (150 to 200 mm) below finished grade. Use multiple tapes where width of multiple lines installed in a common trench exceeds 16 inches (400 mm) overall.
2. Install underground-line warning tape for direct-buried cables and cables in raceways.

J. Cable Ties: General purpose, except as listed below:

1. Outdoors: UV-stabilized nylon.
2. In Spaces Handling Environmental Air: Plenum rated.

3.3 IDENTIFICATION SCHEDULE

A. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.

B. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations with high visibility. Identify by system and circuit designation.

C. Accessible Fittings for Raceways and Cables within Buildings: Identify covers of each junction and pull box with self-adhesive labels containing wiring system legend.

1. System legends shall be as follows:

a. Telecommunications.

D. Faceplates: Label individual faceplates with self-adhesive labels. Place label at top of faceplate. Each faceplate shall be labeled with its individual, sequential designation[**, numbered clockwise when entering room from primary egress**], composed of the following, in the order listed:

1. Wiring closet designation.
2. Colon.
3. Faceplate number.

E. Backbone Cables: Label each cable with a self-adhesive label indicating the location of the far or other end of the backbone cable. Patch panel or punch down block where cable is terminated should be labeled identically.

F. Horizontal Cables: Label each cable with a self-adhesive label indicating the following, in the order listed:

1. Room number.
2. Colon.

3. Faceplate number.

G. Locations of Underground Lines: Underground-line warning tape for copper, coaxial, hybrid copper/fiber, and optical-fiber cable.

H. Equipment Identification Labels:

1. Indoor Equipment: Self-adhesive label.
2. Equipment to Be Labeled:

a. Communications cabinets.
b. Uninterruptible power supplies.
c. Computer room air conditioners.
d. Fire-alarm and suppression equipment.
e. Egress points.
f. Power distribution components.

END OF SECTION 270553

SECTION 271116 - COMMUNICATIONS RACKS, FRAMES, AND ENCLOSURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. 19-inch equipment racks.
2. 19-inch freestanding and wall-mounted equipment cabinets.
3. Open Rack equipment racks.
4. Power strips.
5. Grounding.
6. Labeling.

B. Related Requirements:

1. Section 271110 "Communications Equipment Room Fittings" for backboards and accessories.
2. Section 270526 "Grounding and Bonding for Telecommunications Equipment" for TMGBs and TGBs.
3. Section 270536 "Cable Trays for Communications Systems" for cable trays and cable tray accessories.
4. Section 271313 "Communications Copper Backbone Cabling" for copper data cabling associated with system panels and devices.
5. Section 271323 "Communications Optical Fiber Backbone Cabling" for optical-fiber data cabling associated with system panels and devices.
6. Section 271333 "Communications Coaxial Backbone Cabling" for coaxial data cabling associated with system panels and devices.
7. Section 271513 "Communications Copper Horizontal Cabling" for copper data cabling associated with system panels and devices.
8. Section 271523 "Communications Optical Fiber Horizontal Cabling" for optical-fiber data cabling associated with system panels and devices.
9. Section 271533 "Communications Coaxial Horizontal Cabling" for coaxial data cabling associated with system panels and devices.
10. Section 271611 "Communications Hybrid Cabling" for combined copper and optical fiber data cables associated with system panels and devices.

1.3 DEFINITIONS

A. Access Provider: An operator that provides a circuit path or facility between the service provider and user. An access provider can also be a service provider.

B. BICSI: Building Industry Consulting Service International.

C. LAN: Local area network.

D. RCDD: Registered communications distribution designer.

E. Service Provider: The operator of a telecommunications transmission service delivered through access provider facilities.

F. TGB: Telecommunications grounding bus bar.

G. TMGB: Telecommunications main grounding bus bar.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for equipment racks and cabinets.
2. Include rated capacities, operating characteristics, electrical characteristics, certifications, standards compliance, and furnished specialties and accessories.

B. Shop Drawings: For communications racks, frames, and enclosures. Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Equipment Racks and Cabinets: Include workspace requirements and access for cable connections.
3. Grounding: Indicate location of TGB and its mounting detail showing standoff insulators and wall-mounting brackets.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer**,** qualified layout technician, installation supervisor, and field inspector.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: Cabling installer must have personnel certified by BICSI on staff, not on retainer.

1. Layout Responsibility: Preparation of Shop Drawings shall be under direct supervision of RCDD.
2. Installation Supervision: Installation shall be under direct supervision of New Mexico ES7J who shall be present at all times when Work of this Section is performed at Project site.
3. Field Inspector: Currently registered by BICSI as RCDD to perform on-site inspection.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. UL listed.

B. RoHS compliant.

2.2 BACKBOARDS

A. Backboards: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches (19 by 1220 by 2440 mm). Comply with requirements for plywood backing panels specified in Section 061000 "Rough Carpentry."

2.3 19-INCH EQUIPMENT RACKS

A. Description: four-post racks with threaded rails designed for mounting telecommunications equipment. Width is compatible with EIA/ECIA 310-E, 19-inch (482.6-mm) equipment mounting with an opening of 17.72-inches (450-mm) between rails.

B. General Requirements:

1. Frames: Modular units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.
2. Material: welded steel.
3. Finish: Manufacturer's standard, baked-polyester powder coat.
4. Color: Black
5. Adjustable depth from 36.42in to 42.32in
6. Mounting Hole: #12-24 Threaded

C. Floor-Mounted Racks:

1. Overall Height: **84 inches (2133.6 mm)**].
2. Overall Depth: Adjustable 29 **inches (750 mm)** to 35.4 **inches (900 mm)**]
3. Number of Rack Units per Rack: 45.

4. Threads: 12-24.
5. Vertical and horizontal cable management channels, top and bottom cable troughs, grounding lug, and a power strip.
6. Base shall have a minimum of four mounting holes for permanent attachment to floor.
7. Top shall have provisions for attaching to cable tray or ceiling.

D. Wall-Mounted Racks:

1. Height: 43.1 **inches**.
2. Depth: **25.2 inches**.
3. Load Rating: **100 lb**.
4. Number of Rack Units per Rack: 20
5. Threads: 12-24.
6. Wall Attachment: Minimum Four mounting holes.
7. Equipment Access: Integral swing.

E. Cable Management:
1. Vertical:
   a. Single Sided
   b. Steel and aluminum with plastic T-shaped cable guides
   c. Color: Black
   d. Dual-hinged door opening left or right
2. Horizontal:
   a. Contoured, snap-on frond door opening up or down
   b. Solid chassis
   c. 1 rack unit

2.4 POWER STRIPS

A. Power Strips: Comply with UL 1363.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Horizontal Rack mounting.
3. Eight 20-A, 120-V ac, NEMA WD 6, Configuration 5-20R receptacles.
4. LED indicator lights for power and protection status.
5. LED indicator lights for reverse polarity and open outlet ground.
6. Circuit Breaker and Thermal Fusing: Unit continues to supply power if protection is lost.
7. Cord connected with **8-foot (4.5-m)**] line cord.
8. Rocker-type on-off switch, illuminated when in on position.

2.5 LABELING

A. Comply with TIA-606-B and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.

B. Comply with BICSI TDMM for layout of communications equipment spaces.

C. Bundle, lace, and train conductors and cables to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

D. Coordinate location of power raceways and receptacles with locations of communications equipment requiring electrical power to operate.

3.2 GROUNDING

A. Comply with NECA/BICSI 607.

B. Install grounding according to BICSI ITSIMM, "Bonding, Grounding (Earthing) and Electrical Protection" Ch.

C. Locate TGB to minimize length of bonding conductors. Fasten to wall, allowing at least 2 inches (50 mm) of clearance behind TGB. Connect TGB with a minimum No. 4 AWG grounding electrode conductor from TGB to suitable electrical building ground. Connect rack TGB to near TGB or the TMGB.

3.3 IDENTIFICATION

A. Coordinate system components, wiring, and cabling complying with TIA-606-B. Comply with requirements in Section 270553 "Identification for Electrical Systems."

B. Comply with requirements in Section 099123 "Interior Painting" for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.

C. Labels shall be machine printed. Type shall be **1/8 inch (3 mm** in height.

END OF SECTION 271116

SECTION 271513 - COMMUNICATIONS COPPER HORIZONTAL CABLING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
1. Category 6 twisted pair cable.
2. Twisted pair cable hardware, including plugs and jacks.
3. Cable management system.
4. Cabling identification products.
5. Grounding provisions for twisted pair cable.
6. Source quality control requirements for twisted pair cable.

B. Related Requirements:

1. Section 270513 "Conductors and Cables for Communications Systems" for data cabling associated with system panels and devices.

1.3 DEFINITIONS

A. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.

B. EMI: Electromagnetic interference.

C. FTP: Shielded twisted pair.

D. F/FTP: Overall foil screened cable with foil screened twisted pair.

E. F/UTP: Overall foil screened cable with unscreened twisted pair.

F. IDC: Insulation displacement connector.

G. LAN: Local area network.

H. Jack: Also commonly called an "outlet," it is the fixed, female connector.

I. Plug: Also commonly called a "connector," it is the removable, male telecommunications connector.

J. RCDD: Registered Communications Distribution Designer.

K. Screen: A metallic layer, either a foil or braid, placed around a pair or group of conductors.

L. S/FTP: Overall braid screened cable with foil screened twisted pair.

M. S/UTP: Overall braid screened cable with unscreened twisted pairs.

1.4 COPPER HORIZONTAL CABLING DESCRIPTION

A. Horizontal cable cabling system shall provide interconnections between Distributor A, Distributor B, or Distributor C, and the equipment outlet, otherwise known as "Cabling Subsystem 1," in the telecommunications cabling system structure. Cabling system consists of horizontal cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for horizontal-to-horizontal cross-connection.

1. TIA-568-C.1 requires that a minimum of two equipment outlets be installed for each work area.
2. Horizontal cabling shall contain no more than one transition point or consolidation point between the horizontal cross-connect and the telecommunications equipment outlet.
3. Bridged taps and splices shall not be installed in the horizontal cabling.

B. A work area is approximately 100 sq. ft. (9.3 sq. m), and includes the components that extend from the equipment outlets to the station equipment.

C. The maximum allowable horizontal cable length is 295 feet (90 m). This maximum allowable length does not include an allowance for the length of 16 feet (4.9 m) to the workstation equipment or in the horizontal cross-connect.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Reviewed and stamped by RCDD on staff, not on retainer.
1. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
2. Cabling administration Drawings and printouts.
3. Wiring diagrams and installation details of telecommunications equipment, to show location and layout of telecommunications equipment, including the following:

a. Telecommunications rooms plans and elevations.
b. Telecommunications pathways.
c. Telecommunications system access points.
d. Telecommunications grounding system.
e. Telecommunications conductor drop locations.
f. Typical telecommunications details.
g. Mechanical, electrical, and plumbing systems.

C. Twisted pair cable testing plan.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For RCDD, installation supervisor, and field inspector.

B. Product Certificates: For each type of product.

C. Source quality-control reports.

D. Field quality-control reports.

1.7 CLOSEOUT SUBMITTALS

A. Maintenance Data: For splices and connectors to include in maintenance manuals.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Connecting Blocks: One of each type.
2. Jacks: Ten of each type.
3. Patch-Panel Units: One of each type.

1.9 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

1. Layout Responsibility: Preparation of Shop Drawings and cabling administration Drawings by an RCDD on staff not on retainer.
2. Installation Supervision: Installation shall be under the direct supervision of a New Mexico ES3J who shall be present at all times when Work of this Section is performed at Project site.
3. Testing Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

1.10 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. General Performance: Horizontal cabling system shall comply with transmission standards in TIA-568-C.1, when tested according to test procedures of this standard.

B. Telecommunications Pathways and Spaces: Comply with TIA-569-D.

C. Grounding: Comply with TIA-607-B.

2.2 GENERAL CABLE CHARACTERISTICS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with the applicable standard and NFPA 70 for the following types:

1. Communications, Plenum Rated: Type CMP complying with UL 1685

B. RoHS compliant.

2.3 CATEGORY 6 TWISTED PAIR CABLE

A. Description: Four-pair, balanced-twisted pair cable, with internal spline, certified to meet transmission characteristics of Category 6 cable at frequencies up to 250MHz.

B. Standard: Comply with NEMA WC 66/ICEA S-116-732 and TIA-568-C.2 for Category 6 cables.

C. Conductors: 100-ohm, 23 AWG solid copper.

D. Cable Rating: Plenum.

E. Jacket: Blue thermoplastic.

2.4 TWISTED PAIR CABLE HARDWARE

A. Description: Hardware designed to connect, splice, and terminate twisted pair copper communications cable.

B. General Requirements for Twisted Pair Cable Hardware:

1. Comply with the performance requirements of Category 6.
2. Comply with TIA-568-C.2, IDC type, with modules designed for punch-down caps or tools.
3. Cables shall be terminated with connecting hardware of same category or higher.

C. Connecting Blocks:
1. 110-style IDC for Category 6.

D. Cross-Connect: Modular array of connecting blocks arranged to terminate building cables and permit interconnection between cables.

E. Patch Panel: Modular panels housing numbered jack units with IDC-type connectors at each jack location for permanent termination of pair groups of installed cables.

1. Features:

a. Universal T568A and T568B wiring labels.
b. Labeling areas adjacent to conductors.
c. 48 ports.

2. Construction: 16-gauge steel and mountable on 19-inch (483 mm) equipment racks.
3. Number of Jacks per Field: One for each four-pair cable indicated

F. Patch Cords: Factory-made, four-pair cables in **36-inch (900-mm)** lengths; terminated with an eight-position modular plug at each end.

1. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure performance. Patch cords shall have latch guards to protect against snagging.

G. Plugs and Plug Assemblies:

1. Male; eight position; color-coded modular telecommunications connector designed for termination of a single four-pair, 100-ohm, unshielded or shielded twisted pair cable.
2. Standard: Comply with TIA-568-C.2.

H. Jacks and Jack Assemblies:

1. Female; eight position; modular; fixed telecommunications connector designed for termination of a single four-pair, 100-ohm, unshielded or shielded twisted pair cable.
2. Designed to snap-in to a patch panel or faceplate.
3. Standard: Comply with TIA-568-C.2.

I. Faceplate:

1. Two port, vertical single gang faceplates designed to mount to single gang wall boxes.
2. Plastic Faceplate: High-impact plastic. Coordinate color with Section 262726 "Wiring Devices."
3. Metal Faceplate: Stainless steel located in kitchen area
4. For use with snap-in jacks accommodating any combination of twisted pair, optical fiber, and coaxial work area cords.

J. Legend:

1. Machine printed, in the field, using adhesive-tape label.

2.5 CABLE MANAGEMENT SYSTEM

A. Description: Computer-based cable management system, with integrated database capabilities.

2.6 IDENTIFICATION PRODUCTS

A. Comply with TIA-606-B and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

2.7 GROUNDING

A. Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems" for grounding conductors and connectors.

B. Comply with TIA-607-B.

2.8 SOURCE QUALITY CONTROL

A. Factory test cables on reels according to TIA-568-C.1.

B. Cable will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 WIRING METHODS

A. Wiring Method: Install cables in raceways and cable trays, except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces, attics, and gypsum board partitions where unenclosed wiring method may be used. Conceal raceway and cables, except in unfinished spaces.

1. Install plenum cable in environmental air spaces, including plenum ceilings.
2. Comply with requirements for raceways and boxes specified in Section 270528 "Pathways for Communications Systems."

B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

C. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools. Install conductors parallel with or at right angles to sides and back of enclosure.

3.2 INSTALLATION OF PATHWAYS

A. Comply with requirements for demarcation point, cabinets, and racks specified in Section 271100 "Communications Equipment Room Fittings."

B. Comply with Section 270528 "Pathways for Communications Systems."

C. Comply with Section 270536 "Cable Trays for Communications Systems."

D. Drawings indicate general arrangement of pathways and fittings.

3.3 INSTALLATION OF TWISTED-PAIR HORIZONTAL CABLES

A. Comply with NECA 1 and NECA/BICSI 568.

B. General Requirements for Cabling:

1. Comply with TIA-568-C.0, TIA-568-C.1, and TIA-568-C.2.
2. Comply with BICSI's "Information Transport Systems Installation Methods Manual (ITSIMM), Ch. 5, "Copper Structured Cabling Systems," "Cable Termination Practices" Section.
3. Install 110-style IDC termination hardware unless otherwise indicated.
4. Do not untwist twisted pair cables more than 1/2 inch (12 mm) from the point of termination to maintain cable geometry.
5. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
6. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
7. Install lacing bars to restrain cables, prevent straining connections, and prevent bending cables to smaller radii than minimums recommended by manufacturer.
8. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI Information Transport Systems Installation Methods Manual , Ch. 5, "Copper Structured Cabling Systems," "Cable Termination Practices" Section. Use lacing bars and distribution spools.
9. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation, and replace it with new cable.
10. In the communications equipment room, install a 10-foot- (3-m-) long service loop on each end of cable.
11. Pulling Cable: Comply with BICSI Information Transport Systems Installation Methods Manual, Ch. 5, "Copper Structured Cabling Systems," "Pulling and Installing Cable" Section. Monitor cable pull tensions.

C. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend twisted pair cabling, not in a wireway or pathway, a minimum of 8 inches (200 mm) above ceilings by cable supports not more than **60 inches (1524 mm)** apart.

D. Group connecting hardware for cables into separate logical fields.

E. Separation from EMI Sources:

1. Comply with recommendations from BICSI's "Telecommunications Distribution Methods Manual" and TIA-569-D for separating unshielded copper communication cable from potential EMI sources, including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:

    a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).
    b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches (300 mm).
    c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches (600 mm).

3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:

    a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).
    b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches (150 mm).
    c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches (300 mm).

4. Separation between communications cables in grounded metallic raceways, power lines, and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:

    a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
    b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches (76 mm).
    c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches (150 mm).

5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches (1200 mm).
6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).

3.4 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping."

B. Comply with TIA-569-D, Annex A, "Firestopping."

C. Comply with "Firestopping Systems" Article in BISCI's "Telecommunications Distribution Methods Manual."

3.5 GROUNDING

A. Install grounding according to the "Grounding, Bonding, and Electrical Protection" chapter in BICSI's "Telecommunications Distribution Methods Manual."

B. Comply with TIA-607-B and NECA/BICSI-607.

C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall, allowing at least a 2-inch (50-mm) clearance behind the grounding bus bar. Connect grounding bus bar to suitable electrical building ground, using a minimum No. 4 AWG grounding electrode conductor.

D. Bond metallic equipment to the grounding bus bar, using not smaller than a No. 6 AWG equipment grounding conductor.

3.6 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA-606-B. Comply with requirements for identification specified in Section 270553 "Identification for Communications Systems."

1. Administration Class: Class 2.
2. Color-code cross-connect fields and apply colors to voice and data service backboards, connections, covers, and labels.

B. Cable Schedule: Install in a prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.

C. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors.

D. Cable and Wire Identification:

1. Label each cable within 4 inches (100 mm) of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
2. Each wire connected to building-mounted devices is not required to be numbered at the device if wire color is consistent with associated wire connected and numbered within panel or cabinet.
3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet (4.5 m).
4. Label each terminal strip, and screw terminal in each cabinet, rack, or panel.

    a. Individually number wiring conductors connected to terminal strips, and identify each cable or wiring group, extended from a panel or cabinet to a building-mounted device, with the name and number of a particular device.
    b. Label each unit and field within distribution racks and frames.

5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and -connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.

E. Labels shall be preprinted or computer-printed type, with a printing area and font color that contrast with cable jacket color but still comply with TIA-606-B requirements for the following:

1. Cables use flexible vinyl or polyester that flexes as cables are bent.

3.7 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Visually inspect jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA-568-C.1.
2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.

C. Remove and replace cabling where test results indicate that they do not comply with specified requirements.

D. End-to-end cabling will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

END OF SECTION 271513

SECTION 281500 - ACCESS CONTROL HARDWARE DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Card readers, credential cards, and keypads
2. Cables

B. Related Requirements:

1. Section 281300 "Access Control System Software and Database Management" for control and monitoring applications, workstations, and interfaces.

1.3 DEFINITIONS

A. Credential: Data assigned to an entity and used to identify that entity.

B. DTS: Digital Termination Service. A microwave-based, line-of-sight communication provided directly to the end user.

C. Identifier: A credential card; keypad personal identification number; or code, biometric characteristic, or other unique identification entered as data into the entry-control database for the purpose of identifying an individual. Where this term is presented with an initial capital letter, this definition applies.

D. Location: A Location on the network having a PC-to-controller communications link, with additional controllers at the Location connected to the PC-to-controller link with a TIA 485-A communications loop. Where this term is presented with an initial capital letter, this definition applies.

E. PC: Personal computer. Applies to the central station, workstations, and file servers.

F. RAS: Remote access services.

G. RF: Radio frequency.

H. ROM: Read-only memory. ROM data are maintained through losses of power.

I. TCP/IP: Transport control protocol/Internet protocol.

J. TWAIN: Technology without an Interesting Name. A programming interface that lets a graphics application, such as an image editing program or desktop publishing program, activate a scanner, frame grabber, or other image-capturing device.

K. WMP: Windows media player.

L. Wiegand: Patented magnetic principle that uses specially treated wires embedded in the credential card.

M. WYSIWYG: What You See Is What You Get. Text and graphics appear on the screen the same as they will in print.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Reference each product to a location on Drawings. Test and evaluation data presented in Product Data shall comply with SIA BIO-01.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Diagrams for cable management system.
2. Wiring Diagrams. For power, signal, and control wiring. Show typical wiring schematics including the following:

    a. Workstation outlets, jacks, and jack assemblies.
    b. Patch cords.
    c. Patch panels.

3. Cable Administration Drawings: As specified in "Identification" Article.
4. Battery and charger calculations for central station, workstations, and controllers.

C. Product Schedules.

D. Samples: For workstation outlets, jacks, jack assemblies, and faceplates. For each exposed product and for each color and texture specified.

1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For security system to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Hard copies of manufacturer's specification sheets, operating specifications, design guides, user's guides for software and hardware, and PDF files on USB media of the hard-copy submittal.
2. System installation and setup guides with data forms to plan and record options and setup decisions.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Credential card blanks, ready for printing. Include enough credential cards for all personnel to be enrolled at the site plus an extra 25 percent for future use.
2. Fuses of all kinds, power and electronic, equal to 10 percent of amount installed for each size used, but no fewer than three units.

1.8 QUALITY ASSURANCE

A. Installer Qualifications: An employer of workers trained and approved by manufacturer.

1. Cable installer must have on staff, Not on retainer, an RCDD certified by Building Industry Consulting Service International.

B. Source Limitations: Obtain central station, workstations, controllers, Identifier readers, and all software through one source from single manufacturer.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Store in temperature- and humidity-controlled environment in original manufacturer's sealed containers. Maintain ambient temperature between 50 and 85 deg F (10 and 30 deg C), and not more than 80 percent relative humidity, noncondensing.

B. Open each container; verify contents against packing list; and file copy of packing list, complete with container identification, for inclusion in operation and maintenance data.

C. Mark packing list with the same designations assigned to materials and equipment for recording in the system labeling schedules that are generated by software specified in "Cable and Asset Management Software" Article.

D. Save original manufacturer's containers and packing materials and deliver as directed under provisions covering extra materials.

1.10 PROJECT CONDITIONS

A. Environmental Conditions: System shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:

1. Control Station: Rated for continuous operation in ambient conditions of 60 to 85 deg F (16 to 30 deg C) and a relative humidity of 20 to 80 percent, noncondensing.
2. Indoor, Controlled Environment: NEMA 250, Type 1 enclosure. System components, except the central-station control unit, installed in **air-conditioned** indoor environments shall be rated for continuous operation in ambient conditions of **36 to 122 deg F (2 to 50 deg C)** dry bulb and 20 to 90 percent relative humidity, noncondensing.
3. Indoor, Uncontrolled Environment: NEMA 250, Type 3R enclosures. System components installed in non-air-conditioned indoor environments shall be rated for continuous operation in ambient conditions of **0 to 122 deg F (minus 18 to plus 50 deg C)** dry bulb and 20 to 90 percent relative humidity, noncondensing.

PART 2 - PRODUCTS

2.1 Provide a Vanderbilt SMS deployment. Provide and install equipment necessary for complete operation of systems

2.2 OPERATION

A. Security access system hardware shall use a single database for access-control and credential-creation functions.

2.3 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 70, "National Electrical Code."

2.4 CARD READERS, CREDENTIAL CARDS, AND KEYPADS

A. Provide Xceedid MT15 for wall mount, and MT11 for mullion mount card readers

B. Card-Reader Power: Powered from its associated controller, including its standby power source, and shall not dissipate more than 5 W.

C. Enclosure: Suitable for surface, semi-flush, pedestal, or weatherproof mounting. Mounting types shall additionally be suitable for installation in the following locations:

1. Indoors, controlled environment.
2. Indoors, uncontrolled environment.
3. Outdoors, with built-in heaters or other cold-weather equipment to extend the operating temperature range as needed for operation at the site.

D. Display: Digital visual indicator shall provide visible status indications and user prompts. Indicate power on or off, whether user passage requests have been accepted or rejected, and whether the door is locked or unlocked.

E. Touch-Plate and Proximity Readers:
1. The card reader shall read proximity cards in a range from direct contact to at least 6 inches (150 mm) from the reader.

F. Communication Protocol: Compatible with local processor.

G. Touch-Plate and Contactless Card Reader: The reader shall have "flash" download capability to accommodate card format changes. The card reader shall have capability of transmitting data to security control panel and shall comply with ISO/IEC 7816.

H. Credential Card Modification: Entry-control cards shall be able to be modified by lamination direct print process during the enrollment process without reduction of readability. The design of the credential cards shall allow for the addition of at least one slot or hole to accommodate the attachment of a clip for affixing the credential card to the badge holder used at the site.

I. Card Size and Dimensional Stability: Credential cards shall be **2-1/8 by 3-3/8 inches (54 by 86 mm)**. The credential card material shall be dimensionally stable so that an undamaged card with deformations resulting from normal use shall be readable by the card reader.

J. Card Material: Abrasion resistant, nonflammable, nontoxic, and impervious to solar radiation and effects of ultraviolet light.

K. Card Construction:

1. Core and laminate or monolithic construction.
2. Furnish equipment for on-site assembly and lamination of credential cards.

2.5 PUSH-BUTTON SWITCHES

A. Push-Button Switches: Momentary-contact push buttons with stainless steel switch enclosures.

B. Electrical Ratings:

1. Minimum continuous current rating of 10 A at 120-V ac.

C. Enclosures: Flush or surface mounting. Push buttons shall be suitable for flush mounting in the switch enclosures.

D. Enclosures shall additionally be suitable for installation in the following locations:

1. Indoors, controlled environment.

2.6 CABLES

A. General Cable Requirements: Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" and as recommended by system manufacturer for integration requirement.

2.7 TRANSFORMERS

A. NFPA 70, Class II control transformers, NRTL listed. Transformers for security access-control system shall not be shared with any other system.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine pathway elements intended for cables. Check raceways, cable trays, and other elements for compliance with space allocations, installation tolerances, hazards to cable installation, and other conditions affecting installation.

B. Examine roughing-in for LAN and control cable conduit systems to PCs, controllers, card readers, and other cable-connected devices to verify actual locations of conduit and back boxes before device installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Comply with recommendations in SIA CP-01.

B. Comply with TIA 606-B, "Administration Standard for Commercial Telecommunications Infrastructure."

C. Product Schedules: Obtain detailed product schedules from manufacturer of access-control system or develop product schedules to suit Project. Fill in all data available from Project plans and specifications and publish as Product Schedules for review and approval.

D. In meetings with Architect and Owner, present Product Schedules and review, adjust, and prepare final setup documents. Use approved, final Product Schedules to set up system software.

3.3 CABLING

A. Comply with NECA 1, "Good Workmanship in Electrical Construction."

B. Install cables and wiring according to requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Wiring Method: Install wiring in raceway and cable tray except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Use NRTL-listed plenum cable in environmental airspaces, including plenum ceilings. Conceal raceway and cables except in unfinished spaces.

D. Install LAN cables using techniques, practices, and methods that are consistent with Category 5e rating of components and optical fiber rating of components, and that ensure Category 6 and optical fiber performance of completed and linked signal paths, end to end.

E. Boxes and enclosures containing security-system components or cabling, and which are easily accessible to employees or to the public, shall be provided with a lock. Boxes above ceiling level in occupied areas of the building shall not be considered accessible. Junction boxes and small device enclosures below ceiling level and easily accessible to employees or the public shall be covered with a suitable cover plate and secured with tamperproof screws.

3.4 CABLE APPLICATION

A. Comply with TIA 569-D, "Commercial Building Standard for Telecommunications Pathways and Spaces."

B. Cable application requirements are minimum requirements and shall be exceeded if recommended or required by manufacturer of system hardware.

C. TIA 232-F Cabling: Install at a maximum distance of 50 ft. (15 m) between terminations.

D. TIA 485-A Cabling: Install at a maximum distance of 4000 ft. (1220 m) between terminations.

E. Card Readers and Keypads:

1. Install number of conductor pairs recommended by manufacturer for the functions specified.
2. Unless manufacturer recommends larger conductors, install No. 22 AWG wire if maximum distance from controller to the reader is 250 ft. (75 m), and install No. 20 AWG wire if maximum distance is 500 ft. (150 m).
3. For greater distances, install "extender" or "repeater" modules recommended by manufacturer of the controller.
4. Install minimum No. 18 AWG shielded cable to readers and keypads that draw 50 mA or more.

F. Install minimum No. 16 AWG cable from controller to electrically powered locks. Do not exceed **100 ft.** between terminations.

G. Install minimum No. 18 AWG ac power wire from transformer to controller, with a maximum distance of **25 ft. (8 m)** between terminations.

3.5 GROUNDING

A. Comply with Section 270526 "Grounding and Bonding for Communications Systems."

B. Comply with IEEE 1100, "Recommended Practice for Power and Grounding Electronic Equipment."

C. Ground cable shields, drain conductors, and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.

D. Bond shields and drain conductors to ground at only one point in each circuit.

E. Signal Ground:

1. Terminal: Locate in each equipment room and wiring closet; isolate from power system and equipment grounding.
2. Bus: Mount on wall of main equipment room with standoff insulators.
3. Backbone Cable: Extend from signal ground bus to signal ground terminal in each equipment room and wiring closet.

3.6 INSTALLATION

A. Install card readers, keypads, push buttons.

3.7 IDENTIFICATION

A. In addition to requirements in this article, comply with applicable requirements in Section 270553 "Identification for Communications Systems" and with TIA 606-B.

B. Using software specified in "Cable and Asset Management Software" Article, develop cable administration drawings for system identification, testing, and management. Use unique, alphanumeric designation for each cable, and label cable and jacks, connectors, and terminals to which it connects with the same designation. Use logical and systematic designations for facility's architectural arrangement.

C. Label each terminal strip and screw terminal in each cabinet, rack, or panel.

1. All wiring conductors connected to terminal strips shall be individually numbered, and each cable or wiring group being extended from a panel or cabinet to a building-mounted device shall be identified with the name and number of the particular device as shown.
2. Each wire connected to building-mounted devices is not required to be numbered at the device if the color of the wire is consistent with the associated wire connected and numbered within the panel or cabinet.

D. At completion, cable and asset management software shall reflect as-built conditions.

3.8 SYSTEM SOFTWARE AND HARDWARE

A. Develop, install, and test software and hardware, and perform database tests for the complete and proper operation of systems involved. Assign software license to Owner.

3.9 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. LAN Cable Procedures: Inspect for physical damage and test each conductor signal path for continuity and shorts. Use tester approved for type and kind of installed cable. Test for faulty connectors, splices, and terminations. Test according to TIA 568-C.1, "Commercial Building Telecommunications Cabling Standards - Part 1: General Requirements." Link performance for balanced twisted-pair cables must comply with minimum criteria in TIA 568-C.1.
2. Test each circuit and component of each system. Tests shall include, but are not limited to, measurements of power-supply output under maximum load, signal loop resistance, and leakage to ground where applicable. System components with battery backup shall be operated on battery power for a period of not less than 10 percent of the calculated battery operating time. Provide special equipment and software if testing requires special or dedicated equipment.
3. Operational Test: After installation of cables and connectors, demonstrate product capability and compliance with requirements. Test each signal path for end-to-end performance from each end of all pairs installed. Remove temporary connections when tests have been satisfactorily completed.

C. Devices and circuits will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.10 STARTUP SERVICE

A. Engage a factory-authorized service representative to supervise and assist with startup service.

1. Complete installation and startup checks according to approved procedures that were developed in "Preparation" Article and with manufacturer's written instructions.
2. Enroll and prepare badges and access cards for Owner's operators, management, and security personnel.

3.11 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain security access system. See Section 017900 "Demonstration and Training."

B. Develop separate training modules for the following:

1. Computer system administration personnel to manage and repair the LAN and databases and to update and maintain software.
2. Operators who prepare and input credentials to man the control station and workstations and to enroll personnel.
3. Security personnel.
4. Hardware maintenance personnel.
5. Corporate management.

END OF SECTION 281500

SECTION 271523 - COMMUNICATIONS OPTICAL FIBER HORIZONTAL CABLING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. 62.5/125-micrometer, multimode, optical fiber cable (OM1).
2. 50/125 micrometer, multimode, optical fiber cable (OM2).
3. 850 nanometer laser-optimized 50/125 micrometer multimode optical fiber cable (OM3).
4. 850 nanometer laser-optimized 50/125 micrometer multimode optical fiber cable (OM4).
5. 9/125 micrometer, single mode, optical fiber cable (OS1).
6. 9/125 micrometer, single-mode, indoor-outdoor optical fiber cable (OS2).
7. Optical fiber cable connecting hardware, patch panels, and cross-connects.
8. Grounding.
9. Cabling identification products.

1.3 DEFINITIONS

A. BICSI: Building Industry Consulting Service International.

B. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.

C. RCDD: Registered Communications Distribution Designer.

1.4 OPTICAL FIBER HORIZONTAL CABLING DESCRIPTION

A. Optical fiber horizontal cabling system shall provide interconnections between Distributor A, Distributor B, or Distributor C and the equipment outlet, otherwise known as "Cabling Subsystem 1" in the telecommunications cabling system structure. Cabling system consists of horizontal cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for horizontal-to-horizontal cross-connection.

1. TIA-568-C.1 requires that a minimum of two equipment outlets be installed for each work area.
2. Horizontal cabling shall contain no more than one transition point or consolidation point between the horizontal cross-connect and the equipment outlet.
3. Bridged taps and splices shall not be installed in the horizontal cabling.

B. A work area is approximately 100 sq. ft. (9.3 sq. m), and includes the components that extend from the equipment outlets to the equipment.

C. The maximum allowable horizontal cable length is 295 feet (90 m). This maximum allowable length does not include an allowance for the length of 16 feet (4.9 m) to the workstation equipment or in the horizontal cross-connect.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Reviewed and stamped by RCDD.

1. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
2. Cabling administration Drawings and printouts.
3. Wiring diagrams and installation details of telecommunications equipment, to show location and layout of telecommunications equipment, including the following:

    a. Telecommunications rooms plans and elevations.
    b. Telecommunications pathways.
    c. Telecommunications system access points.
    d. Telecommunications grounding system.
    e. Telecommunications conductor drop locations.
    f. Typical telecommunications details.
    g. Mechanical, electrical, and plumbing systems.

C. Fiber optic cable testing plan.

D. Qualification Data: For RCDD, installation supervisor, and field inspector.

E. Product Certificates: For each type of product.

F. Source quality-control reports.

G. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On USB media or compact disk, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

B. Maintenance Data: For optical fiber cable, splices, and connectors to include in maintenance manuals.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff, not on retainer.

1. Layout Responsibility: Preparation of Shop Drawings, Cabling Administration Drawings, and field testing program development by an RCDD.
2. Installation Supervision: Installation shall be under the direct supervision of a New Mexico ES7J who shall be present at all times when Work of this Section is performed at Project site.
3. Testing Supervisor: Currently certified by BICSI as an RCDD.

1.8 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

1.9 COORDINATION

A. Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications equipment and service suppliers.

1.10 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning with Substantial Completion, provide software support for two years.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. General Performance: Horizontal cabling system shall comply with transmission standards in TIA-568-C.1, when tested according to test procedures of this standard.

B. Telecommunications Pathways and Spaces: Comply with TIA-569-D.

C. Grounding: Comply with TIA-607-B.

2.2 9/125 MICROMETER, SINGLE-MODE, INDOOR-OUTDOOR OPTICAL FIBER CABLE (OS2)

A. Description: Single mode, 9/125-micrometer, 2 fibers, tight buffered, nonconductive optical fiber cable.

B. Maximum Attenuation: 0.5 dB/km at 1310 nm; 0.5 dB/km at 1550 nm.

C. Jacket:

1. Jacket Color: Yellow.
2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-D.
3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches (1000 mm).

D. Standards:

1. Comply with TIA-492CAAB for detailed specifications.
2. Comply with TIA-568-C.3 for performance specifications.
3. Comply with ICEA S-104-696 for mechanical properties.

E. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:

1. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.

2.3 OPTICAL FIBER CABLE HARDWARE

A. Standards:

1. Comply with Fiber Optic Connector Intermateability Standard (FOCIS) specifications of the TIA-604 series.
2. Comply with TIA-568-C.3.

B. Cross-Connects and Patch Panels: Modular panels housing multiple-numbered, duplex cable connectors.

C. Patch Cords: Factory-made, single-fiber cables in 36-inch (900-mm) lengths.

D. Connector Type: Type SC complying with TIA-604-3-B, Type LC complying with TIA-604-10-B connectors.

E. Plugs and Plug Assemblies:

1. Male; color-coded modular telecommunications connector designed for termination of a single optical fiber cable.

2.4 GROUNDING

A. Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems" for grounding conductors and connectors.

B. Comply with TIA-607-B.

2.5 IDENTIFICATION PRODUCTS

A. Comply with TIA-606-B and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

2.6 SOURCE QUALITY CONTROL

A. Factory test preterminated optical fiber cable assemblies according to TIA-526-14-B and TIA-568-C.3.

B. Cable will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 WIRING METHODS

A. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces, in attics, and in gypsum board partitions where unenclosed wiring method may be used. Conceal raceway and cables except in unfinished spaces.

1. Install plenum cable in environmental air spaces, including plenum ceilings.
2. Comply with requirements for pathways specified in Section 270528 "Pathways for Communications Systems."
3. Cabling installed above accessible ceiling space to be installed in J-hook management

B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

C. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

3.2 INSTALLATION OF OPTICAL FIBER BACKBONE CABLES

A. Comply with NECA 1, NECA 301 and NECA/BICSI 568.

B. General Requirements for Optical Fiber Cabling Installation:

1. Comply with TIA-568-C.1 and TIA-568-C.3.
2. Comply with BICSI ITSIMM, Ch. 6, "Cable Termination Practices."
3. Terminate all cables; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
4. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.

5. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
6. Bundle, lace, and train cable to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, "Cabling Termination Practices" Chapter. Use lacing bars and distribution spools.
7. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
8. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
9. In the communications equipment room, provide a 10-foot- (3-m-) long service loop on each end of cable.
10. Pulling Cable: Comply with BICSI ITSIMM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.
11. Cable may be terminated on connecting hardware that is rack or cabinet mounted.

C. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

D. Group connecting hardware for cables into separate logical fields.

3.3 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping."

B. Comply with TIA-569-D, Annex A, "Firestopping."

C. Comply with BICSI ITSIMM, "Firestopping" Chapter.

3.4 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA-606-B. Comply with requirements for identification specified in Section 270553 "Identification for Communications Systems."

1. Administration Class: Class 2.
2. Color-code cross-connect fields and apply colors to voice and data service backboards, connections, covers, and labels.

B. Cable Schedule: Install in a prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.

C. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, horizontal pathways and cables, entrance pathways and cables, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors.

D. Cable and Wire Identification:

1. Label each cable within 4 inches (100 mm) of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet (4.5 m).
4. Label each unit and field within distribution racks and frames.
5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.

E. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA 606-B, for the following:

1. Flexible vinyl or polyester that flexes as cables are bent.

3.5 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Visually inspect optical fiber jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA-568-C.1.
2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
3. Optical Fiber Cable Tests:

a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.1. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
b. Link End-to-End Attenuation Tests:

1) Horizontal and Multimode Horizontal Link Measurements: Test at 850 or 1300 nm in one direction according to TIA-526-14-B, Method B, One Reference Jumper.

2) Attenuation test results for horizontal links shall be less than 2.0 dB. Attenuation test results shall be less than those calculated according to equation in TIA-568-C.1.

C. Data for each measurement shall be documented. Data for submittals shall be printed in a summary report that is formatted similar to Table 10.1 in BICSI TDMM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.

D. Remove and replace cabling where test results indicate that it does not comply with specified requirements.

E. End-to-end cabling will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

END OF SECTION 271523

SECTION 282000 - VIDEO SURVEILLANCE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes a video surveillance system consisting of cameras, Network video recorder, data transmission wiring, and a control station with its associated equipment.

1.3 DEFINITIONS

A. AGC: Automatic gain control.

B. BNC: Bayonet Neill-Concelman - type of connector.

C. B/W: Black and white.

D. CCD: Charge-coupled device.

E. FTP: File transfer protocol.

F. IP: Internet protocol.

G. LAN: Local area network.

H. MPEG: Moving picture experts group.

I. NTSC: National Television System Committee.

J. PC: Personal computer.

K. PTZ: Pan-tilt-zoom.

L. RAID: Redundant array of independent disks.

M. TCP: Transmission control protocol - connects hosts on the Internet.

N. UPS: Uninterruptible power supply.

O. WAN: Wide area network.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include dimensions and data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For video surveillance. Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Functional Block Diagram: Show single-line interconnections between components for signal transmission and control. Show cable types and sizes.
3. Dimensioned plan and elevations of equipment racks, control panels, and consoles. Show access and workspace requirements.

C. Design Data: Include an equipment list consisting of every piece of equipment by model number, manufacturer, serial number, location, and date of original installation. Add pretesting record of each piece of equipment, listing name of person testing, date of test, set points of adjustments, name and description of the view of preset positions, description of alarms, and description of unit output responses to an alarm.

1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Product Warranty: Sample of special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For cameras, power supplies, infrared illuminators, monitors, videotape recorders, digital video recorders, video switches, and control-station components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Lists of spare parts and replacement components recommended to be stored at the site for ready access.

1.7 PROJECT CONDITIONS

A. Environmental Conditions: Capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:

1. Control Station: Rated for continuous operation in ambient temperatures of 60 to 85 deg F (16 to 29 deg C) and a relative humidity of 20 to 80 percent, noncondensing.
2. Interior, Controlled Environment: System components, except central-station control unit, installed in air-conditioned interior environments shall be rated for continuous operation in ambient temperatures of **36 to 122 deg F (2 to 50 deg C)** dry bulb and 20 to 90 percent relative humidity, noncondensing. Use NEMA 250, Type 1 enclosures.

3. Exterior Environment: System components installed in locations exposed to weather shall be rated for continuous operation in ambient temperatures of **minus 30 to plus 122 deg F (minus 34 to plus 50 deg C)** dry bulb and 20 to 90 percent relative humidity, condensing. Rate for continuous operation when exposed to rain as specified in NEMA 250, winds up to 85 mph (137 km/h). Use NEMA 250, Type 3R enclosures.
4. Security Environment: Camera housing for use in high-risk areas where surveillance equipment may be subject to physical violence.

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of cameras, equipment related to camera operation, and control-station equipment that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM REQUIREMENTS

A. Video-signal format shall comply with NTSC standard, composite interlaced video. Composite video-signal termination shall be 75 ohms.

B. Surge Protection: Protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads. Include surge protection for external wiring of each conductor's entry connection to components.

1. Minimum Protection for Power Connections 120 V and More: Auxiliary panel suppressors complying with requirements in Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits."
2. Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Connections: Comply with requirements in Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits" as recommended by manufacturer for type of line being protected.

C. Tamper Protection: Tamper switches on enclosures, control units, pull boxes, junction boxes, cabinets, and other system components shall initiate a tamper-alarm signal when unit is opened or partially disassembled. Control-station, control-unit alarm display shall identify tamper alarms and indicate locations.

2.2 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NECA 1.

C. Comply with NFPA 70.

2.3 STANDARD CAMERAS

A. Coordinate with drawings to provide the following camera types:
   1. Type 1 – Axis P3227-LVE
   2. Type 2 – Axis P3717 (4-in-1)
   3. Type 3 – Axis P3715 (corridor
   4. Type 4 – Axis P3227-LV
   5. Type 5 – Axis Q6010-E
   6. Type 6 – Axis Q6074-E

2.4 NETWORK VIDEO RECORDERS

A. Provide Exacq Vision Z series
   1. Provide with quad NIC
   2. 160TB storage
   3. Provide licensing for each camera + 5 spare licenses

2.5 IP VIDEO SYSTEMS

A. Description:

   1. System shall provide high-quality delivery and processing of IP-based video, audio, and control data using standard Ethernet-based networks.
   2. System shall have seamless integration of all video surveillance and control functions.
   3. Graphical user interface software shall manage all IP-based video matrix switching and camera control functions, two-way audio communication, alarm monitoring and control, and recording and archive/retrieval management. IP system shall also be capable of integrating into larger system environments.
   4. System design shall include all necessary compression software for high-performance, dual-stream, MPEG-2/MPEG-4 video. Unit shall provide connections for all video cameras, camera PTZ control data, bidirectional audio, discreet sensor inputs, and control system outputs.
   5. All camera signals shall be compressed, encoded, and delivered onto the network for processing and control by the IP video-management software.
   6. Camera system units shall be ruggedly built and designed for extreme adverse environments, complying with NEMA Type environmental standards.
   7. Encoder/decoder combinations shall place video, audio, and data network stream that can be managed from multiple workstations on the user's LAN or WAN.
   8. All system interconnect cables, workstation PCs, PTZ joysticks, and network intermediate devices shall be provided for full performance of specified system.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine pathway elements intended for cables. Check raceways and other elements for compliance with space allocations, installation tolerance, hazards to camera installation, and other conditions affecting installation.

B. Examine roughing-in for LAN, WAN, and IP network before device installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 WIRING

A. Comply with requirements in Section 270528 "Pathways for Communications Systems."

B. Wiring Method: Install cables in raceways unless otherwise indicated.

1. Except raceways are not required in accessible indoor ceiling spaces and attics.
2. Except raceways are not required in hollow gypsum board partitions.
3. Conceal raceways and wiring except in unfinished spaces.

C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

D. Splices, Taps, and Terminations: For power and control wiring, use numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

E. For communication wiring, comply with the following:
1. Section 271513 "Communications Copper Horizontal Cabling."

3.3 VIDEO SURVEILLANCE SYSTEM INSTALLATION

A. Install cameras level and plumb.

B. Set pan unit and pan-and-tilt unit stops to suit final camera position and to obtain the field of view required for camera. Connect all controls and alarms, and adjust.

C. Identify system components, wiring, cabling, and terminals according to Section 270553 "Identification for Communications Systems."

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. Inspection: Verify that units and controls are properly installed, connected, and labeled, and that interconnecting wires and terminals are identified.
2. Pretesting: Align and adjust system and pretest components, wiring, and functions to verify that they comply with specified requirements. Conduct tests at varying lighting levels, including day and night scenes as applicable. Prepare video-surveillance equipment for acceptance and operational testing as follows:

    a. Prepare equipment list described in "Informational Submittals" Article.
    b. Verify operation of auto-iris lenses.
    c. Set back-focus of fixed focal length lenses. At focus set to infinity, simulate nighttime lighting conditions by using a dark glass filter of a density that produces a clear image. Adjust until image is in focus with and without the filter.
    d. Set back-focus of zoom lenses. At focus set to infinity, simulate nighttime lighting conditions by using a dark glass filter of a density that produces a clear image. Additionally, set zoom to full wide angle and aim camera at an object 50 to 75 feet (17 to 23 m) away. Adjust until image is in focus from full wide angle to full telephoto, with the filter in place.
    e. Set and name all preset positions; consult Owner's personnel.
    f. Set sensitivity of motion detection.
    g. Connect and verify responses to alarms.
    h. Verify operation of control-station equipment.
3. Operational Tests: Perform operational system tests to verify that system complies with Specifications. Include all modes of system operation. Test equipment for proper operation in all functional modes.

C. Video surveillance system will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.5 ADJUSTING

A. Occupancy Adjustments: When requested within 6 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to one visit to Project during other-than-normal occupancy hours for this purpose. Tasks shall include, but are not limited to, the following:

1. Check cable connections.
2. Check proper operation of cameras and lenses. Verify operation of auto-iris lenses and adjust back-focus as needed.
3. Adjust all preset positions; consult Owner's personnel.
4. Recommend changes to cameras, lenses, and associated equipment to improve Owner's use of video surveillance system.

3.6 CLEANING

A. Clean installed items using methods and materials recommended in writing by manufacturer.

B. Clean video-surveillance-system components, including camera-housing windows, lenses, and monitor screens.

3.7 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain video-surveillance equipment.

END OF SECTION 282000

SECTION 28 3111 - DIGITAL, ADDRESSABLE FIRE-ALARM SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Comply with NFPA 5000, 2000ED for a Class A system.

1.2 SUMMARY

A. Section Includes:

1. Fire-alarm control unit.
2. Manual fire-alarm boxes.
3. System smoke detectors.
4. Heat detectors.
5. Notification appliances.
6. Device guards.
7. Magnetic door holders.
8. Remote annunciator.
9. Addressable interface device.
10. Digital alarm communicator transmitter.
11. Radio alarm transmitter.
12. Network communications.
13. System printer.

1.3 DEFINITIONS

A. EMT: Electrical Metallic Tubing.

B. FACP: Fire Alarm Control Panel.

C. HLI: High Level Interface.

D. NICET: National Institute for Certification in Engineering Technologies.

E. PC: Personal computer.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product, including furnished options and accessories.

1. Include construction details, material descriptions, dimensions, profiles, and finishes.
2. Include rated capacities, operating characteristics, and electrical characteristics.

B. Shop Drawings: For fire-alarm system.

1. Comply with recommendations and requirements in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
2. Include plans, elevations, sections, details, and attachments to other work.
3. Include details of equipment assemblies. Indicate dimensions, weights, loads, and required clearances, method of field assembly, components, and locations. Indicate conductor sizes, indicate termination locations and requirements, and distinguish between factory and field wiring.
4. Detail assembly and support requirements.
5. Include voltage drop calculations for notification-appliance circuits.
6. Include battery-size calculations.1
7. Include input/output matrix.
8. Include statement from manufacturer that all equipment and components have been tested as a system and meet all requirements in this Specification and in NFPA 72.
9. Include performance parameters and installation details for each detector.
10. Verify that each duct detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
11. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale; coordinate location of duct smoke detectors and access to them.
    a. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators.
    b. Show field wiring required for HVAC unit shutdown on alarm.
    c. Show field wiring and equipment required for HVAC unit shutdown on alarm and override by firefighters' control system.
    d. Show field wiring and equipment required for HVAC unit shutdown on alarm and override by firefighters' smoke-evacuation system.
    e. Locate detectors according to manufacturer's written recommendations.
12. Include voice/alarm signaling-service equipment rack or console layout, grounding schematic, amplifier power calculation, and single-line connection diagram.
13. Include floor plans to indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits and point-to-point wiring diagrams.
14. General Submittal Requirements: Submit three (3) copies of the Fiore Alarm shop drawings, battery calculations, voltage drop calculations, equipment data sheets, sequence of operation, fire alarm riser, and all related documents through the project manager to the Division of safety and Risk Management (AHJ) for review and approval prior to installation. [25 IAM Safety and Health Handbook Topic 26, 26.6.A4]

C. General Submittal Requirments

1. Submittals shall be approved by authorities having jurisdiction, State or local fire Marshall, prior to submitting them to Architect.
2. Shop Drawings shall be prepared by persons with the following qualifications:
    a. Trained and certified by manufacturer in fire-alarm system design.
    b. NICET-certified, fire-alarm technician; Level III minimum.
    c. Licensed or certified by authorities having jurisdiction.

D. Delegated-Design Submittal: For notification appliances and smoke and heat detectors, in addition to submittals listed above, indicate compliance with performance requirements and

design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Drawings showing the location of each notification appliance and smoke and heat detector, ratings of each, and installation details as needed to comply with listing conditions of the device.
2. Design Calculations: Calculate requirements for selecting the spacing and sensitivity of detection, complying with NFPA 72. Calculate spacing and intensities for strobe signals and sound-pressure levels for audible appliances.
3. Indicate audible appliances required to produce square wave signal per NFPA 72.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Seismic Qualification Data: Certificates, for fire-alarm control unit, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

D. Sample Warranty: For special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 01 7800 "Closeout Submittals" include the following and deliver copies to authorities having jurisdiction:

a. Comply with the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
b. Provide "Fire Alarm and Emergency Communications System Record of Completion Documents" according to the "Completion Documents" Article in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
c. Complete wiring diagrams showing connections between all devices and equipment. Each conductor shall be numbered at every junction point with indication of origination and termination points.
d. Riser diagram.
e. Device addresses.
f. Record copy of site-specific software.

g. Provide "Inspection and Testing Form" according to the "Inspection, Testing and Maintenance" chapter in NFPA 72, and include the following:

1) Equipment tested.
2) Frequency of testing of installed components.
3) Frequency of inspection of installed components.
4) Requirements and recommendations related to results of maintenance.
5) Manufacturer's user training manuals.

h. Manufacturer's required maintenance related to system warranty requirements.
i. Abbreviated operating instructions for mounting at fire-alarm control unit and each annunciator unit.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On magnetic media or compact disk, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

C. Acceptance:

The following documents shall be provided to DSRM, through the project manager, PRIOR to final Inspection:

1. “Record of Completion”(NFPA72, 7.5.5.2).Written Statement that the system has been installed in accordance with approved plan, tested in accordance with Manufacturer’s specifications and NFPA requirements (NFPA 72,, 7.5.2).

The following shall be available for examination at final inspection:

1. Operations & Maintenance Manual, Including manufacturer’s published instructions and installation instructions, covering all system equipment (NFPA 72, 7.2.1(6)).
2. As-built installation drawings (NFPA 72, 7.2.1(14))

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Lamps for Remote Indicating Lamp Units: Quantity equal to 10 percent of amount installed, but no less than one unit.
2. Lamps for Strobe Units: Quantity equal to 10 percent of amount installed, but no less than one unit.
3. Smoke Detectors, Fire Detectors: Quantity equal to 10 percent of amount of each type installed, but no less than one unit of each type.
4. Detector Bases: Quantity equal to 10 percent of amount of each type installed, but no less than one unit of each type.
5. Keys and Tools: One extra set for access to locked and/or tamper proofed components.
6. Audible and Visual Notification Appliances: Two of each type installed.
7. Fuses: Two of each type installed in the system. Provide in a box or cabinet with compartments marked with fuse types and sizes.

1.8 QUALITY ASSURANCE

A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.

B. Installer Qualifications: Installation shall be by personnel certified by NICET as fire-alarm Level III technician.

C. NFPA Certification: Obtain certification according to NFPA 72 by an NRTL (nationally recognized testing laboratory).

D. NFPA Certification: Obtain certification according to NFPA 72 in the form of a placard by an FM Global-approved alarm company.

1.9 PROJECT CONDITIONS

A. Perform a full test of the system. Document any equipment or components not functioning as designed.

B. Use of Devices during Construction: Protect devices during construction unless devices are placed in service to protect the facility during construction.

1.10 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace fire-alarm system equipment and components that fail in materials or workmanship within specified warranty period.

1. Warranty Extent: All equipment and components not covered in the Maintenance Service Agreement.
2. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Source Limitations for Fire-Alarm System and Components: Components shall be compatible with, and operate as an extension of, existing system. Provide system manufacturer's certification that all components provided have been tested as, and will operate as, a system.

B. Noncoded, UL-certified addressable system, with multiplexed signal transmission and voice and or horn]/strobe evacuation.

C. Automatic sensitivity control of certain smoke detectors.

D. All components provided shall be listed for use with the selected system.

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 SYSTEMS OPERATIONAL DESCRIPTION

A. Fire-alarm signal initiation shall be by one or more of the following devices and systems:

1. Manual stations.
2. Heat detectors.
3. Smoke detectors.
4. Duct smoke detectors.
5. Carbon monoxide detectors.
6. Combustible gas detectors.
7. Automatic sprinkler system water flow.
8. Fire-extinguishing system operation.
9. Fire standpipe system.
10. Dry system pressure flow switch.

B. Fire-alarm signal shall initiate the following actions:

1. Continuously operate alarm notification appliances, including voice evacuation notices.
2. Identify alarm and specific initiating device at fire-alarm control unit and remote annunciators.
3. Transmit an alarm signal to the remote alarm receiving station.
4. Unlock electric door locks in designated egress paths.
5. Release fire and smoke doors held open by magnetic door holders.
6. Activate voice/alarm communication system.
7. Switch heating, ventilating, and air-conditioning equipment controls to fire-alarm mode.
8. Activate smoke-control system (smoke management) at firefighters' smoke-control system panel.
9. Activate stairwell and elevator-shaft pressurization systems.
10. Close smoke dampers in air ducts of designated air-conditioning duct systems.
11. Activate preaction system.
12. Recall elevators to primary or alternate recall floors.
13. Activate elevator power shunt trip.
14. Activate emergency lighting control.
15. Activate emergency shutoffs for gas and fuel supplies.
16. Record events in the system memory.
17. Record events by the system printer.
18. Indicate device in alarm on the graphic annunciator.

C. Supervisory signal initiation shall be by one or more of the following devices and actions:

1. Valve supervisory switch.
2. High- or low-air-pressure switch of a dry-pipe or preaction sprinkler system.
3. Alert and Action signals of air-sampling detector system.
4. Elevator shunt-trip supervision.
5. Independent fire-detection and -suppression systems.
6. User disabling of zones or individual devices.
7. Loss of communication with any panel on the network.

D. System trouble signal initiation shall be by one or more of the following devices and actions:

1. Open circuits, shorts, and grounds in designated circuits.

2. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
3. Loss of communication with any addressable sensor, input module, relay, control module, remote annunciator, printer interface, or Ethernet module.
4. Loss of primary power at fire-alarm control unit.
5. Ground or a single break in internal circuits of fire-alarm control unit.
6. Abnormal ac voltage at fire-alarm control unit.
7. Break in standby battery circuitry.
8. Failure of battery charging.
9. Abnormal position of any switch at fire-alarm control unit or annunciator.
10. Voice signal amplifier failure.
11. Hose cabinet door open.

E. System Supervisory Signal Actions:

1. Initiate notification appliances.
2. Identify specific device initiating the event at fire-alarm control unit and remote annunciators.
3. Record the event on system printer.
4. After a time delay of 200 seconds, transmit a trouble or supervisory signal to the remote alarm receiving station.
5. Transmit system status to building management system.
6. Display system status on graphic annunciator.

2.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Fire-alarm control unit and raceways shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.4 FIRE-ALARM CONTROL UNIT

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Gamewell - FCI by Honeywell.
2. Firelite.

B. General Requirements for Fire-Alarm Control Unit:

1. Field-programmable, microprocessor-based, modular, power-limited design with electronic modules, complying with UL 864.

a. System software and programs shall be held in nonvolatile flash, electrically erasable, programmable, read-only memory, retaining the information through failure of primary and secondary power supplies.

b. Include a real-time clock for time annotation of events on the event recorder and printer.
c. Provide communication between the FACP and remote circuit interface panels, annunciators, and displays.
d. The FACP shall be listed for connection to a central-station signaling system service.
e. Provide nonvolatile memory for system database, logic, and operating system and event history. The system shall require no manual input to initialize in the event of a complete power down condition. The FACP shall provide a minimum 500-event history log.

2. Addressable Initiation Device Circuits: The FACP shall indicate which communication zones have been silenced and shall provide selective silencing of alarm notification appliance by building communication zone.
3. Addressable Control Circuits for Operation of Notification Appliances and Mechanical Equipment: The FACP shall be listed for releasing service.

C. Alphanumeric Display and System Controls: Arranged for interface between human operator at fire-alarm control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.

1. Annunciator and Display: Liquid-crystal type, 80 characters, minimum.
2. Keypad: Arranged to permit entry and execution of programming, display, and control commands.

D. Alphanumeric Display and System Controls: Arranged for interface between human operator at fire-alarm control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.

1. Annunciator and Display: Liquid-crystal type, three line(s) of 80 characters, minimum.
2. Keypad: Arranged to permit entry and execution of programming, display, and control commands for control of smoke-detector sensitivity and other parameters.

E. Initiating-Device, Notification-Appliance, and Signaling-Line Circuits:

1. Pathway Class Designations: NFPA 72, Class A.
2. Pathway Survivability: Level 1.
3. Install no more than 100 addressable devices on each signaling-line circuit.
4. Serial Interfaces:
   a. One dedicated RS 485 port for central-station operation using point ID DACT.
   b. One RS 485 port for remote annunciators, Ethernet module, or multi-interface module (printer port).
   c. One USB and RS 232 port for PC configuration.
   d. One RS 232 port for voice evacuation interface.

5. Fire Alarm System shall be provided with Class A Wiring, 14 gauge minimum. [BIA School Design Handbook 11100-1]

F. Smoke-Alarm Verification:

1. Initiate audible and visible indication of an "alarm-verification" signal at fire-alarm control unit.
2. Activate an approved "alarm-verification" sequence at fire-alarm control unit and detector.
3. Record events by the system printer.
4. Sound general alarm if the alarm is verified.
5. Cancel fire-alarm control unit indication and system reset if the alarm is not verified.

G. Notification-Appliance Circuit:

1. Audible appliances shall sound in a three-pulse temporal pattern, as defined in NFPA 72.
2. Where notification appliances provide signals to sleeping areas, the alarm signal shall be a 520-Hz square wave with an intensity 15 dB above the average ambient sound level or 5 dB above the maximum sound level, or at least 75 dBA, whichever is greater, measured at the pillow.
3. Visual alarm appliances shall flash in synchronization where multiple appliances are in the same field of view, as defined in NFPA 72.

H. Door Controls: Door hold-open devices that are controlled by smoke detectors at doors in smoke-barrier walls shall be connected to fire-alarm system.

I. Remote Smoke-Detector Sensitivity Adjustment: Controls shall select specific addressable smoke detectors for adjustment, display their current status and sensitivity settings, and change those settings. Allow controls to be used to program repetitive, time-scheduled, and automated changes in sensitivity of specific detector groups. Record sensitivity adjustments and sensitivity-adjustment schedule changes in system memory, and print out the final adjusted values on system printer.

J. The kitchen hood fire protection system will be monitored by the FACP.

K. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm station.

L. Voice/Alarm Signaling Service: Central emergency communication system with redundant microphones, preamplifiers, amplifiers, and tone generators provided in a separate cabinet located in the fire command center.

1. Indicate number of alarm channels for automatic, simultaneous transmission of different announcements to different zones or for manual transmission of announcements by use of the central-control microphone. Amplifiers shall comply with UL 1711.

    a. Allow the application of, and evacuation signal to, indicated number of zones and, at the same time, allow voice paging to the other zones selectively or in any combination.
    b. Programmable tone and message sequence selection.
    c. Standard digitally recorded messages for "Evacuation" and "All Clear."
    d. Generate tones to be sequenced with audio messages of type recommended by NFPA 72 and that are compatible with tone patterns of notification-appliance circuits of fire-alarm control unit.

2. Status Annunciator: Indicate the status of various voice/alarm speaker zones and the status of firefighters' two-way telephone communication zones.
3. Preamplifiers, amplifiers, and tone generators shall automatically transfer to backup units, on primary equipment failure.

M. Printout of Events: On receipt of signal, print alarm, supervisory, and trouble events. Identify zone, device, and function. Include type of signal (alarm, supervisory, or trouble) and date and time of occurrence. Differentiate alarm signals from all other printed indications. Also print system reset event, including same information for device, location, date, and time. Commands initiate the printing of a list of existing alarm, supervisory, and trouble conditions in the system and a historical log of events.

N. Primary Power: 24-V dc obtained from 120-V ac service and a power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, supervisory and digital alarm communicator transmitters, and digital alarm radio transmitters shall be powered by 24-V dc source.

1. Alarm current draw of entire fire-alarm system shall not exceed 80 percent of the power-supply module rating.

O. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.

1. Batteries: Vented, wet-cell pocket, plate nickel cadmium.

P. Instructions: Computer printout or typewritten instruction card mounted behind a plastic or glass cover in a stainless-steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions.

2.5 MANUAL FIRE-ALARM BOXES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Gamewell - FCI by Honeywell.
2. Firelite.

B. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes shall be finished in red with molded, raised-letter operating instructions in contrasting color; shall show visible indication of operation; and shall be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.

1. Single-action mechanism, breaking-glass or plastic-rod pull-lever type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.
2. Double-action mechanism requiring two actions to initiate an alarm, breaking-glass or plastic-rod type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.
3. Station Reset: Key- or wrench-operated switch.

4. Indoor Protective Shield: Factory-fabricated, clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm. Lifting the cover actuates an integral battery-powered audible horn intended to discourage false-alarm operation.
5. Weatherproof Protective Shield: Factory-fabricated, clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm.

2.6 SYSTEM SMOKE DETECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Gamewell - FCI by Honeywell.
2. Firelite.

B. General Requirements for System Smoke Detectors:

1. Comply with UL 268; operating at 24-V dc, nominal.
2. Detectors shall be four-wire type.
3. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
4. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
5. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
6. Integral Visual-Indicating Light: LED type, indicating detector has operated and power-on status.
7. Remote Control: Unless otherwise indicated, detectors shall be digital-addressable type, individually monitored at fire-alarm control unit for calibration, sensitivity, and alarm condition and individually adjustable for sensitivity by fire-alarm control unit.
    a. Rate-of-rise temperature characteristic of combination smoke- and heat-detection units shall be selectable at fire-alarm control unit for 15 or 20 deg F per minute.
    b. Fixed-temperature sensing characteristic of combination smoke- and heat-detection units shall be independent of rate-of-rise sensing and shall be settable at fire-alarm control unit to operate at 135 or 155 deg F.
    c. Multiple levels of detection sensitivity for each sensor.
    d. Sensitivity levels based on time of day.
8. Locate detectors at least 5’-0” from supply air grilles.
9. Locate detectors at least 12” from luminaires.
10. Consider stratification effects when selecting detector locations.
11. Heat detectors will be provided for any kitchens, boiler rooms, electrical rooms, kiln rooms, or other locations where dirt or debris are likely to cause false alarms.
12. Heat detectors will be intermediate fixed temperature rated.

C. Photoelectric Smoke Detectors:

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.

2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:

    a. Primary status.
    b. Device type.
    c. Present average value.
    d. Present sensitivity selected.
    e. Sensor range (normal, dirty, etc.).

D. Ionization Smoke Detector:

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:

    a. Primary status.
    b. Device type.
    c. Present average value.
    d. Present sensitivity selected.
    e. Sensor range (normal, dirty, etc.).

E. Duct Smoke Detectors: Photoelectric type complying with UL 268A.

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:

    a. Primary status.
    b. Device type.
    c. Present average value.
    d. Present sensitivity selected.
    e. Sensor range (normal, dirty, etc.).

3. Provide duct detectors in supply and return ducts for air handling units (AHU's) with air velocity of 2,000 cubic feet per minute or greater.

4. Ensure that duct detectors are located prior to any duct splits, or provide a duct detector on each branch of duct work where required for complete coverage.
5. Remote indicator lights and test switches shall be provided for each duct detector.

    a. Locate the detector in the nearest corridor or other common space, wall mounted at 7'-0" above finished floor. Provide permanent label indicating which duct detector is at that location.
    b. When a duct detector is concealed above a ceiling provide a permanent label on the access door or the ceiling tile used for service access to the duct detector, indicating which duct detector is at that location.

6. Provide duct detector with-in 5'-0" of each fire/smoke damper.

7. Activation of a duct detector will shut down the associated unit.

8. Manual override shall be provided for testing of AHU shutdown upon duct detector activation.
9. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector for smoke detection in HVAC system ducts.
10. Each sensor shall have multiple levels of detection sensitivity.
11. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
12. Relay Fan Shutdown: Fully programmable relay rated to interrupt fan motor-control circuit.

2.7 CARBON MONOXIDE DETECTORS

A. General: Carbon monoxide detector listed for connection to fire-alarm system.

1. Mounting: Adapter plate for outlet box mounting.
2. Testable by introducing test carbon monoxide into the sensing cell.
3. Detector shall provide alarm contacts and trouble contacts.
4. Detector shall send trouble alarm when nearing end-of-life, power supply problems, or internal faults.
5. Comply with UL 2075.
6. Locate, mount, and wire according to manufacturer's written instructions.
7. Provide means for addressable connection to fire-alarm system.
8. Test button simulates an alarm condition.

2.8 HEAT DETECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Gamewell - FCI by Honeywell.
2. Firelite.

B. General Requirements for Heat Detectors: Comply with UL 521.

1. Temperature sensors shall test for and communicate the sensitivity range of the device.

C. Heat Detector, Combination Type: Actuated by either a fixed temperature of 135 deg F or a rate of rise that exceeds 15 deg F per minute unless otherwise indicated.

1. Mounting: Twist-lock base interchangeable with smoke-detector bases.
2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

D. Heat Detector, Fixed-Temperature Type: Actuated by temperature that exceeds a fixed temperature of 190 deg F.

1. Mounting: Twist-lock base interchangeable with smoke-detector bases.
2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

2.9 NOTIFICATION APPLIANCES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Gamewell - FCI by Honeywell.
2. Firelite.

B. General Requirements for Notification Appliances: Individually addressed, connected to a signaling-line circuit, equipped for mounting as indicated, and with screw terminals for system connections.

C. Provide a sufficient number of horns/speakers spaced as required to achieve 15 decibels above ambient sound levels and 4 decibels above the maximum sound level in each space.

D. General Requirements for Notification Appliances: Connected to notification-appliance signal circuits, zoned as indicated, equipped for mounting as indicated, and with screw terminals for system connections.

1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated, and with screw terminals for system connections.
2. Provide horns/speakers as required by code and in each corridor, cafeteria, classroom, vocal room, instrumental room, mechanical room, break room, sound proof room, and sleeping rooms.
3. Provide gymnasiums, and auditoriums with either live or pre-recorded voice announcements or visible devices.
4. Where gymnasiums, auditoriums, cafeterias, and the like have a local sound system, provide the means to disengage the sound system upon activation of the fire alarm system and initiate a pre-recorded voice announcement. Provide a local override to allow for live announcements. The override shall time out and resume the pre-recorded message with-in 10 seconds after the end of the live message.

E. Chimes, Low-Level Output: Vibrating type, 75-dBA minimum rated output.

F. Chimes, High-Level Output: Vibrating type, 81-dBA minimum rated output.

G. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Comply with UL 464. Horns shall produce a sound-pressure level of 90 dBA, measured 10 feet from the horn, using the coded signal prescribed in UL 464 test protocol.

H. Visible Notification Appliances: Xenon strobe lights complying with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch-high letters on the lens.

1. Rated Light Output:

a. Will vary depending on location and volume of space, any of the following could be used: 15, 30, 75, 110, 177, cd.
b. 15/30/75/110 cd, selectable in the field.

2. Mounting: Wall mounted unless otherwise indicated.
3. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.
4. Flashing shall be in a temporal pattern, synchronized with other units.
5. Strobe Leads: Factory connected to screw terminals.
6. Mounting Faceplate: Factory finished, white.
7. The candela level provided by the strobes shall be coordinated with the application and location as required to meet code requirements.
8. Provide strobes as required by code and in each corridor, cafeteria, classroom, vocal room, instrumental room, mechanical room, break room, sound proof room, and sleeping rooms

I. Provide separate circuits to the horns and strobes to enable separate horn/speaker silence features.

J. Provide audible/visual notification with-in 15’-0” of all exits.

K. Provide an exterior weatherproof horn/strobe at the fire department Siamese connection or at the point of entry of the fire department where a Siamese connection is not located.

L. Provide two-way communication between areas of refuge and the FACP.

M. Voice/Tone Notification Appliances:

1. Comply with UL 1480.
2. Speakers for Voice Notification: Locate speakers for voice notification to provide the intelligibility requirements of the "Notification Appliances" and "Emergency Communications Systems" chapters in NFPA 72.
3. High-Range Units: Rated 2 to 15 W.
4. Low-Range Units: Rated 1 to 2 W.
5. Mounting: Flush or surface mounted and bidirectional.
6. Matching Transformers: Tap range matched to acoustical environment of speaker location.

N. Exit Marking Audible Notification Appliance:

1. Exit marking audible notification appliances shall meet the audibility requirements in NFPA 72.
2. Provide exit marking audible notification appliances at the entrance to all building exits.
3. Provide exit marking audible notification appliances at the entrance to areas of refuge with audible signals distinct from those used for building exit marking.

2.10 MAGNETIC DOOR HOLDERS

A. Description: Units are equipped for wall or floor mounting as indicated and are complete with matching doorplate.

1. Electromagnets: Require no more than 3 W to develop 25-lbf holding force.
2. Wall-Mounted Units: Flush mounted unless otherwise indicated.
3. Rating: 24-V ac or dc.

4. Rating: 120-V ac.

B. Material and Finish: Match door hardware.

C. Configure door hold-opens to close upon any alarm.

D. Coordinate voltage requirements for magnetic door hold-opens.

E. Coordinate door hold-opens with security requirements.

2.11 REMOTE ANNUNCIATOR

A. Description: Annunciator functions shall match those of fire-alarm control unit for alarm, supervisory, and trouble indications. Manual switching functions shall match those of fire-alarm control unit, including acknowledging, silencing, resetting, and testing.

1. Mounting: Flush cabinet, NEMA 250, Type 1.

B. Display Type and Functional Performance: Alphanumeric display and LED indicating lights shall match those of fire-alarm control unit. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

2.12 DIGITAL ALARM COMMUNICATOR TRANSMITTER

A. Digital alarm communicator transmitter shall be acceptable to the remote central station and shall comply with UL 632.

B. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire-alarm control unit and automatically capture two telephone line(s) and dial a preset number for a remote central station. When contact is made with central station(s), signals shall be transmitted. If service on either line is interrupted for longer than 45 seconds, transmitter shall initiate a local trouble signal and transmit the signal indicating loss of telephone line to the remote alarm receiving station over the remaining line. Transmitter shall automatically report telephone service restoration to the central station. If service is lost on both telephone lines, transmitter shall initiate the local trouble signal.

C. Local functions and display at the digital alarm communicator transmitter shall include the following:

1. Verification that both telephone lines are available.
2. Programming device.
3. LED display.
4. Manual test report function and manual transmission clear indication.
5. Communications failure with the central station or fire-alarm control unit.

D. Digital data transmission shall include the following:

1. Address of the alarm-initiating device.
2. Address of the supervisory signal.

3. Address of the trouble-initiating device.
4. Loss of ac supply.
5. Loss of power.
6. Low battery.
7. Abnormal test signal.
8. Communication bus failure.

E. Secondary Power: Integral rechargeable battery and automatic charger.

F. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

2.13 NETWORK COMMUNICATIONS

A. Provide network communications pathway per manufacturer's written requirements and requirements in NFPA 72 and NFPA 70.

2.14 SYSTEM PRINTER

A. Printer shall be listed and labeled as an integral part of fire-alarm system.

2.15 DEVICE GUARDS

A. Description: Welded wire mesh of size and shape for the manual station, smoke detector, gong, or other device requiring protection.

1. Factory fabricated and furnished by device manufacturer.
2. Finish: Paint of color to match the protected device.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for ventilation, temperature, humidity, and other conditions affecting performance of the Work.

1. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment and wiring are installed, before installation begins.

B. Examine roughing-in for electrical connections to verify actual locations of connections before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 EQUIPMENT INSTALLATION

A. Comply with NFPA 72, NFPA 101, ADAA/BAAG, 2004ED, and requirements of authorities having jurisdiction for installation and testing of fire-alarm equipment. Install all electrical wiring to comply with requirements in NFPA 70 including, but not limited to, Article 760, "Fire Alarm Systems."

1. Devices placed in service before all other trades have completed cleanup shall be replaced.
2. Devices installed but not yet placed in service shall be protected from construction dust, debris, dirt, moisture, and damage according to manufacturer's written storage instructions.

B. Connecting to Existing Equipment: Verify that existing fire-alarm system is operational before making changes or connections.

1. Connect new equipment to existing control panel in existing part of the building.
2. Connect new equipment to existing monitoring equipment at the supervising station.
3. Expand, modify, and supplement existing control/monitoring equipment as necessary to extend existing control/monitoring functions to the new points. New components shall be capable of merging with existing configuration without degrading the performance of either system.

C. Install wall-mounted equipment, with tops of cabinets not more than 78 inches above the finished floor.

1. Comply with requirements for seismic-restraint devices specified in Section 270548.16 "Seismic Controls for Communications Systems."

D. Manual Fire-Alarm Boxes:

1. Install manual fire-alarm box in the normal path of egress within 60 inches of the exit doorway.
2. Mount manual fire-alarm box on a background of a contrasting color.
3. The operable part of manual fire-alarm box shall be between 42 inches and 48 inches above floor level. All devices shall be mounted at the same height unless otherwise indicated.

E. Smoke- or Heat-Detector Spacing:

1. Comply with the "Smoke-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for smoke-detector spacing.
2. Comply with the "Heat-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for heat-detector spacing.
3. Smooth ceiling spacing shall not exceed 30 feet.
4. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas shall be determined according to Annex A or Annex B in NFPA 72.
5. HVAC: Locate detectors not closer than 36 inches from air-supply diffuser or return-air opening.
6. Lighting Fixtures: Locate detectors not closer than 12 inches from any part of a lighting fixture and not directly above pendant mounted or indirect lighting.

F. Install a cover on each smoke detector that is not placed in service during construction. Cover shall remain in place except during system testing. Remove cover prior to system turnover.

G. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct. Tubes more than 36 inches long shall be supported at both ends.

1. Do not install smoke detector in duct smoke-detector housing during construction. Install detector only during system testing and prior to system turnover.

H. Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location. Do not install smoke detectors in sprinklered elevator shafts.

I. Single-Station Smoke Detectors: Where more than one smoke alarm is installed within a dwelling or suite, they shall be connected so that the operation of any smoke alarm causes the alarm in all smoke alarms to sound.

J. Remote Status and Alarm Indicators: Install in a visible location near each smoke detector, sprinkler water-flow switch, and valve-tamper switch that is not readily visible from normal viewing position.

K. Audible Alarm-Indicating Devices: Install not less than 6 inches below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille. Install all devices at the same height unless otherwise indicated.

L. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 6 inches below the ceiling. Install all devices at the same height unless otherwise indicated.

M. Device Location-Indicating Lights: Locate in public space near the device they monitor.

N. Antenna for Radio Alarm Transmitter: Mount to building structure where indicated. Use mounting arrangement and substrate connection that resists 100-mph wind load with a gust factor of 1.3 without damage.

3.3 PATHWAYS

A. Pathways above recessed ceilings and in non-accessible locations may be routed exposed.

1. Exposed pathways located less than 96 inches above the floor shall be installed in EMT.

B. Pathways shall be installed in ¾” EMT minimum.

C. Exposed EMT shall be painted red enamel.

3.4 CONNECTIONS

A. For fire-protection systems related to doors in fire-rated walls and partitions and to doors in smoke partitions, comply with requirements in Section 087100 "Door Hardware." Connect hardware and devices to fire-alarm system.

1. Verify that hardware and devices are listed for use with installed fire-alarm system before making connections.

B. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 36 inches from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.

1. Alarm-initiating connection to smoke-control system (smoke management) at firefighters' smoke-control system panel.
2. Alarm-initiating connection to stairwell and elevator-shaft pressurization systems.
3. Smoke dampers in air ducts of designated HVAC duct systems.
4. Magnetically held-open doors.
5. Electronically locked doors and access gates.
6. Alarm-initiating connection to elevator recall system and components.
7. Alarm-initiating connection to activate emergency lighting control.
8. Alarm-initiating connection to activate emergency shutoffs for gas and fuel supplies.
9. Supervisory connections at valve supervisory switches.
10. Supervisory connections at low-air-pressure switch of each dry-pipe sprinkler system.
11. Supervisory connections at elevator shunt-trip breaker.
12. Data communication circuits for connection to building management system.
13. Data communication circuits for connection to mass notification system.
14. Supervisory connections at fire-extinguisher locations.

3.5 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 27 0553 "Identification for Communications Systems."

B. Install framed instructions in a location visible from fire-alarm control unit.

3.6 GROUNDING

A. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.

B. Ground shielded cables at the control panel location only. Insulate shield at device location.

3.7 FIELD QUALITY CONTROL

A. Field tests shall be witnessed by Architect, authorities having jurisdiction, and Owner.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.

D. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Visual Inspection: Conduct visual inspection prior to testing.

    a. Inspection shall be based on completed record Drawings and system documentation that is required by the "Completion Documents, Preparation" table in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
    b. Comply with the "Visual Inspection Frequencies" table in the "Inspection" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.

2. System Testing: Comply with the "Test Methods" table in the "Testing" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
3. Test audible appliances for the public operating mode according to manufacturer's written instructions. Perform the test using a portable sound-level meter complying with Type 2 requirements in ANSI S1.4.
4. Test audible appliances for the private operating mode according to manufacturer's written instructions.
5. Test visible appliances for the public operating mode according to manufacturer's written instructions.
6. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" section of the "Fundamentals" chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

E. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.

F. Provide a 48 hour battery test and a 90 minute alarm test.

G. Fire-alarm system will be considered defective if it does not pass tests and inspections.

H. Prepare test and inspection reports.

I. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.

J. Annual Test and Inspection: One year after date of Substantial Completion, test fire-alarm system complying with visual and testing inspection requirements in NFPA 72. Use forms developed for initial tests and inspections.

3.8 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by skilled employees of manufacturer's designated service organization. Include preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

1. Include visual inspections according to the "Visual Inspection Frequencies" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
2. Perform tests in the "Test Methods" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
3. Perform tests per the "Testing Frequencies" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

3.9 SOFTWARE SERVICE AGREEMENT

A. Comply with UL 864.

B. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.

C. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule access to system and to upgrade computer equipment if necessary.

3.10 DEMONSTRATION

A. After final inspection engage a factory-authorized service representative to must train Owner's maintenance personnel onsite to adjust, operate, and maintain fire-alarm system indicated in the approved operating and maintenance instructions.

END OF SECTION 28 3111

SECTION 31 0000

EARTHWORK

PART 1 GENERAL

1.01 DESCRIPTION OF WORK

A. Extent of earthwork shall be as indicated on drawings and shall include excavation, filling, backfilling, compaction, and grading under and around structures, and remainder of site as shown on plans.

1. Preparation of subgrade for building foundations, slabs and exterior walkways is included as part of this work.
2. Backfilling of trenches beyond building lines is included as part of this work.
3. Site Grading is included as part of this work.

1.02 DEFINITIONS

A. "Excavation" consists of removal of material encountered to subgrade elevations indicated and subsequent disposal of materials removed.

B. "Unauthorized Excavation" consists of removal of materials beyond indicated subgrade elevations or dimensions without specific instructions from the Engineer to do so.

1.03 REFERENCES

A. General: The documents referenced in this section are declared to be a part of these specifications, the same as if fully set forth, except modified herein. Except as specifically stated otherwise, the edition or revision of each document which is in effect at the beginning of work on this project shall be used.

B. Geotechnical Investigation:

1. Geotechnical Evaluation Report; Western Technologies Job No. 3120JS042, dated May 18, 2020.

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

1. ASTM D422 Standard Test Method for Particle Size Analysis of Soils
2. ASTM D1556 Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method
3. ASTM D1557 Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3 (2700KN-m/m3))
4. ASTM D2922 Standard Test Method for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)
5. ASTM D4318 Standard Test Method for Liquid Limit, Plastic Limit and Plasticity Index of Soils

D. NFPA 5000, “Building Construction and Safety Codes”: Soils

E. New Mexico Standard Specifications for Public Works Construction, Latest Edition, including all updates, and applicable laws, codes, and regulations.

F. 29 CFR 1926 Construction Industry Regulations (OSHA)

1.04 QUALITY ASSURANCE

A. Codes and Standards: Perform excavation work in compliance with applicable requirements of governing authorities having jurisdiction.

B. Testing and Inspection Service: The Owner shall employ a Testing Laboratory acceptable to Engineer to perform testing and inspection services for quality control testing during earthwork operations.

1.05 SUBMITTALS

A. Fill and Backfill Materials: Gradation and moisture-density relationship for each material proposed for use as fill or backfill.

1.06 JOB CONDITIONS

A. Bench Marks: Protect benchmarks on or adjacent to site from damage. If benchmarks are damaged, restore as required by authorities having jurisdiction.

B. Unexpected Conditions: Notify Engineer and Owner's representative of unexpected subsurface conditions. Discontinue affected work in area until notified to resume work.

C. Existing Utilities:

1. Identify existing underground utilities in areas of work located by Owner. If utilities are to remain in place, provide adequate means of support and protection during earthwork operations.

2. If uncharted, or incorrectly charted, piping or other utilities are encountered during excavation, consult utility owner immediately for directions. Cooperate with Owner and utility companies in keeping respective services and facilities in operation. Repair damaged utilities to satisfaction of utility owner.

D. Protection of Persons and Property:

1. Barricade open excavations occurring as part of this work and post with warning lights.

2. Operate warning lights as recommended by authorities having jurisdiction.

3. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout and other hazards created by earthwork operations.

PART 2 - PRODUCTS

2.01 SOIL MATERIALS

A. Structural Backfill and Fill Materials: Clean material free of debris, waste, frozen materials, vegetation, clay lumps and other deleterious materials and having the physical characteristics as specified in the Geotechnical Report. The plasticity index should be 10 (max) when tested in accordance with ASTM D-4318.

B. Pipe bedding material shall be processed natural material meeting the gradation requirements as specified in the geotechnical report. The plasticity index of the material used for pipe bedding shall not exceed 10 as determined by ASTM D4318.

C. Base Course: New Mexico Department of Transportation Standard Specifications for Highway and Bridge Construction, Latest Edition, Section 304.

PART 3 - EXECUTION

3.01 CLEARING AND GRUBBING:

A. General: Clearing and grubbing will be required for areas indicated on the Drawings to be excavated, improved or on which fill is to be constructed. Cleared and grubbed materials, including trash, shall be deposited to an approved disposal site.

B. Clearing: Clearing shall consist of removal and disposal of existing paving materials, concrete and vegetation as well as matted roots, brush and rubbish within the areas to be improved and constructed upon.

C. Grubbing: Stumps, matted roots and roots larger than two (2) inches in diameter shall be removed from within eight (8) inches of the surface of areas on which improvements and fills are to be constructed except in roadways. Materials as described above and which are within eighteen (18) inches of finished subgrade of roadways in either cut or fill sections shall be removed. Areas disturbed by grubbing shall be filled as specified in the Geotechnical Report for engineered fill and backfill.

D. Inspection: Cleared and excavated areas shall be inspected by Geotechnical Engineer prior to scarifying and placing fills.

1. Identify required lines, levels, contours and datum.
2. Identify known underground utilities located by Owner. Protect stakes and flags installed by Owner.
3. Identify and flag surface and aerial utilities.
4. Notify utility companies to remove or relocate utilities as necessary.
5. Maintain and protect existing utilities which pass through site.

3.02 EXCAVATION AND TRENCHING

A. General: The Contractor shall perform all excavation and trenching of every description and of whatever substances encountered to the depths indicated on the contract drawings or as otherwise specified. During excavation and trenching, material suitable for backfilling shall be piled in an orderly manner a sufficient distance from the banks of the trench to avoid overloading and to prevent slides or cave-ins. All excavated material not required or suitable for backfilling shall be removed and wasted. Berming and grading shall be done as may be necessary to prevent surface water from flowing into excavated areas or trenches. Any water accumulating therein shall be removed by pumping or by other methods.

B. Excavation For Footings: Over excavation, moisture conditioning and backfill shall be as indicated in the General Foundation Notes. Excavation shall be adequate with allowances made for clearance to install services, forms, waterproofing and dampproofing. The bottom of the excavation shall be accurately graded, level, clean and clear of loose materials. Overdepth shall be backfilled with specified backfill material at the Contractor's expense. Undercutting will not be permitted.

C. Trenching For Utilities: Trenches shall be adequate width for the proper laying of the pipe and the banks shall be as nearly vertical as practicable and safe for workmen. The bottom of the trenches shall be accurately graded and bedded to provide uniform bearing and support for each section of the pipe at every point along its entire length. Bell holes and depressions for joints shall be dug after the trench bottom has been graded and bedded in order that the pipe rests upon the prepared bottom for its full length. Care shall be taken not to excavate below the depths indicated to a minimum overdepth of 4 inches below the trench depths. Overdepths in

the rock and common excavation shall be backfilled with backfill material. Whenever wet or otherwise unstable soil that is incapable of properly supporting the pipe is encountered in the bottom of the trench, such soil shall be removed to the depth required and the trench backfilled to the proper grade with materials as specified.

D. Inspection: Cleared and excavated areas shall be inspected by Geotechnical Engineer prior to scarifying and placing fills.
   1. Identify required lines, levels, contours and datum.
   2. Identify known underground utilities located by Owner. Protect stakes and flags installed by Owner.
   3. Identify and flag surface and aerial utilities.
   4. Notify utility companies to remove or relocate utilities as necessary.
   5. Maintain and protect existing utilities which pass through site.

3.03 EXCAVATION

A. General:
   1. Excavate to subgrade elevations indicated.
   2. Unauthorized excavation, as well as remedial work directed by Engineer, shall be at Contractor's expense.

B. Additional Excavation:
   1. When excavation has reached required subgrade elevations, notify Engineer who will make an inspection of conditions.
   2. If unsuitable bearing materials are encountered at required subgrade elevations, notify Engineer. Do not continue excavating without specific instructions to do so from the Engineer and replace excavated material as directed by Engineer.
   3. Removal of unsuitable material and its replacement as directed will be paid on basis of contract conditions relative to changes in work.

C. Stability of Excavations:
   1. Slope sides of excavations to comply with local codes and ordinances having jurisdiction, OSHA requirements, and as required for slope stability based on site conditions. Shore and brace where sloping is not possible because of space restrictions or stability of material excavated.
   2. Maintain sides and slopes of excavations in safe condition until completion of backfilling.

D. Dewatering:
   1. Prevent surface water and subsurface or groundwater from flowing into excavations and from flooding project site and surrounding area.
   2. Do not allow water to accumulate in excavations. Remove water to prevent softening of foundation bottoms, undercutting footings, and soil changes detrimental to stability of subgrades and foundations. Provide and maintain pumps, well points, sumps, suction and discharge lines, and other dewatering system components necessary to convey water away from excavations. Use methods, materials and equipment as necessary to prevent damage to existing construction.

3. Establish and maintain temporary drainage ditches and other diversions outside excavation limits to convey rainwater and water removed from excavations to collecting or run-off areas. Do not use trench excavations as temporary drainage ditches.

E. Material Storage:

1. Stockpile satisfactory excavated materials where directed, until required for backfill or fill. Place, grade and shape stockpiles for proper drainage.
2. Locate and retain soil materials away from edge of excavations. Do not store within drip line of trees indicated to remain.
3. Dispose of excess soil material and waste materials off site in accordance with local codes and ordinances.
4. Excavation for Structures:
5. Conform to elevations and dimensions shown within a tolerance of plus or minus 0.10 foot, and extending a sufficient distance from footings and foundations to permit placing and removal of concrete formwork, installation of services, other construction, and for inspection.

F. Cold Weather Protection:

1. Protect excavation bottoms against freezing.

3.04 FILL AND BACKFILL

A. Begin fill and backfill operations as promptly as work permits, but not until completion of the following:

1. Acceptance of construction below finish grade including, where applicable, damp proofing, waterproofing, and perimeter insulation.
2. Inspection, testing, approval, and recording locations of underground utilities.
3. Removal of concrete formwork.
4. Removal of trash and debris.
5. Permanent or temporary horizontal bracing is in place on horizontally supported walls.

B. Site Preparation:

1. This site shall be prepared by removing and clearing any existing foundations, paved areas, grass, trees, tree roots, and organic topsoils where indicated on the construction drawings.
2. The Subgrade shall be proof rolled to detect local weak areas which should be excavated, processed, and recompacted in loose lifts of approximately 10-inch (Maximum) thickness and compacted to a minimum of 95% of maximum dry density (per Geotechnical Report).

C. Subgrade Preparation:

1. The top 8 inches of in-place soil shall be plowed or scarified, processed to near optimum moisture and compacted per the Geotechnical Report.
2. The site shall be proof rolled to detect soft areas which should be removed and properly replaced.
3. Subgrade shall be tested by a qualified Laboratory Technician under the supervision of a Registered Professional Engineer specializing in geotechnical studies.

D. Placement:

1. All select fill material shall have properties specified in, and be placed per, the Geotechnical Report. All soil for fill shall be free of large rock (larger than 2") or other deleterious material. The plasticity index and liquid limit of material used as select, non-expansive fill shall be

routinely verified during fill placement using laboratory tests. Visual observation and classification shall not be relied upon to confirm the material to be used as select, non-expansive fill satisfies the above Atterberg-limit criteria.

2. The site shall be proof rolled to detect soft areas which should be removed and properly replaced.
3. Each lift shall be tested by a qualified Laboratory Technician under the supervision of a Registered Professional Engineer specializing in geotechnical studies.

3.05 GRADING

A. General: Uniformly grade areas within limits of grading under this section, including adjacent transition areas. Smooth finished surface within specified tolerances, compact with uniform levels or slopes between points where elevations are indicated, or between such points and existing grades.

B. Grading Outside Building Lines: Grade areas adjacent to building lines to drain away from structures and to prevent ponding.

C. Finish surfaces free from irregular surface changes, and as follows:

1. Lawn or Unpaved Areas: Finish areas to receive topsoil to within not more than 0.10' above or below required subgrade elevations.
2. Walks: Shape surface of areas under walks to line, grade and cross-section, with finish surface not more than 0.10' above or below required subgrade elevation.

D. Compaction: After grading, compact subgrade surfaces to the depth and indicated percentage of maximum density for each area classification.

3.06 MAINTENANCE

A. Protection of Graded Areas: Protect newly graded areas from traffic and erosion. Keep free of trash and debris.

B. Repair and re-establish grades in settled, eroded, and rutted areas to specified tolerances.

C. Reconditioning Compacted Areas: Where completed compacted areas are disturbed by subsequent construction operations or adverse weather, scarify surface, re-shape, and compact to required density prior to further construction.

D. Settling: Where settling is measurable or observable at excavated areas during general project warranty period, remove surface (pavement, lawn or other finish), add backfill material, compact, and replace surface treatment. Restore appearance, quality, and condition of surface or finish to match adjacent work and eliminate evidence of restoration to greatest extent possible.

E. Any previously tested and approved areas requiring maintenance re-work shall be re-tested prior to acceptance.

3.07 DISPOSAL OF EXCESS AND WASTE MATERIALS

A. Remove waste materials, including trash and debris, and properly dispose of it off Owner's property.

B. Coordinate with owner and engineer for placement of excess excavated material for stockpile location on Owner's property.

3.08 FIELD QUALITY CONTROL

A. An independent testing laboratory, selected and paid for by the Owner and approved by the Engineer, shall be retained to perform construction testing of in-place materials.

Testing and inspection shall include, but is not limited to, the following tests. Testing and inspection shall be performed by a licensed Geotechnical Engineering firm or its representative.

1. Determine maximum densities and optimum moisture contents in accordance with ASTM D-1557.
2. Determine in-place density by either the sand-cone method (ASTM D1556) or the nuclear method (ASTM D2922).

B. Test subgrade; fill materials and embankments at the following rates:

1. One field density test for each 500 square yards of subgrade.
2. One field density test for each 500 cubic yards of fill or for each fill layer, whichever results in the greater number of tests.
3. One moisture-density for each type of subgrade material encountered and each type of fill material used, as indicated by sieve analysis and plasticity index.

C. If testing results indicate that density of in-place material is less than that required, recompact and retest until requirements of this specification are met. Costs of retesting are the Contractor's expense.

D. Provide Engineer written notification 48 hours in advance of when testing will be conducted. Conduct tests in presence of Engineer or Engineer’s representative.

END OF SECTION

SECTION 312000 -EARTHWORK

PART 1 GENERAL

1.01 WORK INCLUDED

A. The work covered by this Section consists of furnishing all plant, labor, equipment, appurtenances and material in performing all operations, hauling, placing, spreading, watering, processing, compacting and shaping earth sections complete in place in accordance with the Project Manual and Drawings.

1.02 RELATED WORK ELSEWHERE

A. Section 31 10 00 - Clearing

B. General foundation notes on Drawings. In case of conflict or omission, the general foundation notes shall govern.

1.03 SUBSURFACE SOIL DATA

A. Subsurface soil investigations have been made and the results are available for examination by the Contractor. This is not a warranty of conditions, the Contractor is expected to examine the site and determine for himself the character of materials to be encountered.

B. No additional allowance will be made for rock removal, site clearing and grading, filling, compaction, disposal, or removal of any unclassified materials.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM).

1.	ASTM D 1556-90	Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.
2.	ASTM D 1557-91	Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3).
3.	ASTM D 2922-96	Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
4.	ASTM D 3017-96	Standard Test Method for Water content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).
5.	ASTM D 4318-95a	Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

1.05 SUBMITTALS

A. Submit copies of materials certificates and test results for materials in accordance with type of tests, frequencies and remarks as outlined in the sampling and testing schedule.

1.06 TESTING AND INSPECTION

A. General: The Contractor shall employ the services of a registered, licensed Geotechnical Engineer to observe all controlled earthwork soil testing. The testing laboratory shall provide continuous on-site observation by experienced personnel during construction of fill material. The Contractor shall notify the testing laboratory at least two working days in advance of any field operations of controlled earthwork, or of any resumption of operations after stoppages.

B. Report of Field Density Tests

1. The Geotechnical Engineer shall submit, daily, the results of field density tests required by these specifications.

C. Costs of Tests and Inspection

1. The cost of testing, inspecting and engineering, as specified in this section of the specifications, shall be borne by the Contractor.

D. Lines and Grades: Alignment and grade of all elements shall be made on true tangents and curves. Grades shall conform to the elevations indicated on Drawings, with minor adjustments, to provide a smooth approach at building lines, at connections to existing paving and to provide proper drainage. Correct irregularities at no cost to the Owner.

1.07 WEATHER LIMITATIONS

A. Controlled fill shall not be constructed when the atmospheric temperature is below 35 degrees F. When the temperature falls below 35 degrees, it shall be the responsibility of the Contractor to protect all areas of completed work against any detrimental effects of ground freezing by methods approved by the testing laboratory. Any areas that are damaged by freezing shall be reconditioned, reshaped, and compacted by the Contractor in conformance with the requirements of this specification without additional cost to the Owner.

PART 2 PRODUCTS

2.01 NON - STRUCTURAL FILL MATERIAL

A. The material shall be clean, free of roots, organic matter, trash, debris, lumps or stones larger than 6 inches.

2.02 STRUCTURAL FILL MATERIAL

A. Material shall consist of soils that conform to the following physical characteristics:

Sieve Size Sq. Openings	Percent Passing By Weight
6 inch	100
4 inch	85 – 100
¾ inch	70 - 100
No. 4	50 - 100
No. 200	40 (max)

B. Maximum expansive potential (%)……1.5
C. Maximum soluble sulfates (%)……..0.10

PART 3 EXECUTION

3.01 PREPARATION

A. Clearing and Grubbing: Prior to placing structural fill all borrow areas and areas to receive structural fill shall be stripped of vegetation and deleterious materials. Strippings shall be hauled offsite or stockpiled for subsequent use in landscaped areas or non-structural fill areas as designated by the Owner or his representative and approved by the Geotechnical Engineer.

3.02 CONSTRUCTION AREA TREATMENT

A. Site Preparation - Fill Areas: Prior to placing structural fill the areas to be filled shall be scarified to a depth of eight inches and moisture conditioned as described below. The area to be filled shall then be compacted to a minimum of 95 percent of maximum density as determined in accordance with ASTM D 1557. Any soft or "spongy" areas shall be removed as directed by the Geotechnical Engineer and replaced with structural fill as described herein.

B. Site Preparation - Cut Areas: Following excavation to rough grade all building and pavement areas shall be scarified to a depth of eight inches and moisture conditioned as described below. All building and paved areas shall be compacted to a minimum of 95 percent of maximum density as determined by ASTM D 1557.

3.03 EQUIPMENT AND METHODS

A. In areas not accessible to heavy equipment, distribute by and compact with hand operated vibratory compactors.

3.04 BORROW

A. The Contractor shall provide sufficient material for fill to the lines, elevations and cross sections as shown on the contract drawings from borrow areas.

B. The Contractor shall obtain from the Owners of said borrow areas the right to excavate material, shall pay all royalties and other charges involved, and shall pay all expenses in developing the source including the cost of right-of-way required for hauling the material.

3.05 COMPACTION

A. Fill shall be spread in layers not exceeding 8 inches, watered as necessary, and compacted. Moisture content at time of compaction shall be 3 percent below optimum moisture or higher. A density of not less than 95 percent of maximum dry density within the building pads and paved areas shall be obtained. Fill areas outside the building pads and paved areas shall be compacted to 95 percent of maximum dry density.

B. Optimum moisture content and maximum dry density for each soil type used shall be determined in accordance with ASTM D 1557.

C. Compaction of the fill shall be by mechanical means only. Where vibratory compaction equipment is used, it shall be the Contractor's responsibility to ensure that the vibrations do not damage nearby buildings or other adjacent property. Where vibratory compaction is not possible, pneumatic rolling equipment shall be used.

MATERIAL	MINIMUM PERCENT COMPACTION
Structural & granular fill in construction area	95
Subgrade below structural fill	95
Structural fill under exterior walls	95
Subgrade under asphalt & sidewalks	95
Miscellaneous backfill	90

3.06 MOISTURE CONTROL

A. The material, while being compacted, shall be within the moisture range of 3% below to 3% above optimum, well distributed throughout the layer.

3.07 DENSITY REQUIREMENTS

A. Density of undisturbed soils, in-place fill and backfill shall be determined in accordance with the procedures of ASTM D 1556 or ASTM D 2922 and D 3017. If tests indicate that the density of in-place soil is less than required, the material shall be scarified, moistened or dried as necessary to obtain proper moisture content and recompacted as necessary to achieve the proper densities. Sufficient density tests shall be made and

reports submitted by the Testing Laboratory indicating all cut and fill areas were compacted and graded in accordance with the requirements.

3.08 SLOPE PROTECTION & DRAINAGE

A. Berming and grading shall be done as may be necessary to prevent surface water from flowing into and out of the construction area. Any water accumulating therein shall be removed by pumping or by other methods.

3.09 SOIL EROSION PROTECTION

A. The Contractor shall ensure that no soil erodes or blows from the site into public right-of-way or onto private property.

B. The Contractor shall promptly clean up any material which erodes or blows into the public right-of-way or onto private property.

3.10 PRESERVATION OF PROPERTY

A. Provide temporary fences, barricades, coverings, or other protections to preserve existing items indicated to remain and to prevent injury or damage to persons or property. Apply protections to adjacent properties as required.

B. Restore damaged work to condition existing prior to start of work, unless otherwise directed.

3.11 EXISTING UTILITIES

A. The Contractor shall verify the location of any utility lines, pipelines, or underground utility lines in or near the area of the work in advance of and during Earthwork. The Contractor is fully responsible for any and all damage caused by failure to locate, identify and preserve any and all existing utilities, pipelines and underground utility lines. Repair damaged utilities to the satisfaction of the utility owner at no expense to the Owner.

B. Should uncharted or incorrectly charted piping or other utilities be encountered during grading, consult the Architect immediately for directions as to procedures.

C. Cooperate with the Owner and public or private utility companies in keeping service and facilities in operation.

3.12 WASTE

A. Dispose of all waste off Owner's property.

B. Burning of waste will not be permitted.

3.13 AIR POLLUTION

A. Use water sprinkling, temporary enclosures, and other suitable methods to limit dust and dirt air pollution. Comply with governing regulations pertaining to environmental protection.

SAMPLING AND TESTING SCHEDULE
FOR EARTHWORK

FIELD QUALITY CONTROL

MATERIAL	TEST FOR	FREQUENCY	REMARKS
NATURAL GROUND	Compaction in accordance with ASTM D 1556 or ASTM D 2922 and D 3017	1 per 500 square yards of surface	Conduct a minimum of 2 tests on each section.
EMBANKMENT AND/OR SUBGRADE	Soil Conditions Moisture-Density in Accordance with ASTM D 1557	Test 1 per soil Classification	
	Compaction control in accordance with ASTM D 1556 or ASTM D 3017	1 per each lift every 300 square yards of surface	1) Immediately after placing 2) Conduct a minimum of 2 tests per section
		1 per each lift for each 100 cubic yards of fill	

END OF SECTION 312000

SECTION 32 1200
FLEXIBLE PAVING

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. All materials shall be as indicated on Drawings and shall comply with applicable NMDOT Standard Specifications, Latest Edition, regarding source, quality, gradation, mix design proportioning, measurement and payment.

1.02 SUBMITTALS

A. Design Mix: Before any asphalt concrete paving is constructed, submit actual design mix to the Engineer for review and/or approval. Design mix submittal shall follow the format as indicated in the NMDOT Standard Specifications, Latest Edition.
B. Material Certificates: Submit materials certificate to onsite independent testing laboratory, which is signed by material producer and Contractor, certifying that materials comply with, or exceed, the requirements herein.

1.03 JOB CONDITIONS

A. Weather Limitations
    1. Apply prime and tack coats when ambient temperature is above 40°, and when temperature has been above 35° for 12 hours immediately prior to application. Do not apply when subgrade is wet or contains excess moisture.
    2. Construct asphalt concrete paving when atmospheric temperature is above 40°.

PART 2 PRODUCTS

2.01 MATERIALS

A. Provide asphalt-aggregate mixture as recommended by local or state paving authorities to suit project conditions. Use locally available materials and gradations which meet NMDOT Standard Specifications, Latest Edition and exhibit satisfactory record on previous installations.
B. Mineral Filler: Rock or slag dust, hydraulic cement, or other inert material complying with AASHTO M-17/ASTM D 242, if recommended by applicable New Mexico standards.
C. Asphalt Cement: Comply with AASHTO M-226/ASTM D 3381; AC-20, AR-80, viscosity grade.
D. Tack Coat: Emulsified asphalt; AASHTO M-140/ASTM D 997 or M 208/ASTM D 2397, SS-1h, CSS-1, or Css-1h, diluted with one-part water to one-part emulsified asphalt.
E. Asphalt-Aggregate Mixture: Per NMDOT Standard Specifications, Latest Edition.

2.02 EQUIPMENT

Maintain equipment in satisfactory operating condition and correct breakdowns in a manner that will not delay or be detrimental to progress of paving operations.

PART 3 EXECUTION

3.01 PREPARATION

A. Remove loose material from compacted base material surface immediately before applying prime coat.
B. Proof roll prepared base material surface to check for unstable areas and areas requiring additional compaction.
C. Do not begin paving work until deficient base material areas have been corrected and are ready to receive paving.

3.02 APPLICATIONS

A. Prime Coat

1. Apply bituminous prime coat to all base material surfaces where asphalt concrete paving will be constructed.
2. Apply bituminous prime coat in accordance with NMDOT Standard Specifications, Latest Edition.
3. Apply at minimum rate of 0.1 to 0.3 gallons per square yard over compacted base material. Apply to penetrate and seal, but not flood surface.
4. Make necessary precautions to protect adjacent areas from over-spray.
5. Cure and dry as long as necessary to attain penetration and evaporation of volatile components.

B. Tack Coat

1. Apply tack coat to contact surfaces of previously constructed asphalt concrete base courses or Portland cement concrete and surfaces abutting or projecting into asphalt concrete and surfaces abutting or projecting into asphalt concrete pavement.
2. Apply tack coat to asphalt concrete base course or sand asphalt base course. Apply emulsified asphalt tack coat between each lift or layer of full depth asphalt concrete and sand asphalt bases and on surface of all such bases where asphalt concrete paving will be constructed.
3. Apply emulsified asphalt tack coat in accordance with NMDOT Standard Specifications, Latest Edition.
4. Apply at minimum rate of 0.03 to 0.12 gallon per square yard of surface.
5. Allow to dry until at proper condition to receive paving.

3.03 ASPHALTIC CONCRETE PLACEMENT

A. Place asphaltic concrete as per NMDOT Standard Specifications, Latest Edition.

B. Place asphalt concrete mixture on completed compacted subgrade surface, spread, and strike off. Spread mixture at following minimum temperatures:

1. When ambient temperature is between 40º F and 50º F: 285º F.
2. When ambient temperature is between 50º F and 60º F: 280º F.
3. When ambient temperature is higher than 60º F: 275º F.

C. Place inaccessible and small areas by hand. Place each course to required grade, cross-section, and compacted thickness.

D. Paving Machine Placement: Apply successive lifts of asphalt concrete in transverse directions with the surface course placed in the direction of surface-water flow. Place in typical strips not less than 10' - 0" wide.

E. Joints: Make joints between old and new pavements, or between successive days' work, to ensure continuous bond between adjoining work. Construct joints to have same texture, density, and smoothness as other sections of asphalt concrete course. Clean contact surfaces and apply tack coat.

F. Asphalt Concrete Curbs: Construct asphalt curbs over compacted pavement surfaces only when indicated on Drawings. Apply light tack coat unless pavement surface is still tacky and free from dust. Place curb materials to cross-section indicated by machine or by hand in wood or metal forms. Tamp hand-placed materials and screed to smooth finish. Remove forms as soon as material has cooled.

3.04 ROLLING AND COMPACTION

A. Rolling and Compaction shall be accomplished per NMDOT Standard Specifications, Latest Edition.

B. The mixture, after being spread, shall be thoroughly compacted by rolling as soon as it will bear the weight of the rollers without undue displacement. The number, weight, and types of rollers

and sequences of rolling operations shall be such that the required density and surface are consistently attained while the mixture is in a workable condition.

C. Compact mixture with hot hand tampers or vibrating plate compactors in areas inaccessible to rollers.

D. Breakdown Rolling: Accomplish breakdown or initial rolling immediately following rolling of joints and outside edge. Check surface after breakdown rolling, and repair displaced areas by loosening and filling, if required, with hot material.

E. Second Rolling: Follow breakdown rolling as soon as possible, while mixture is hot. Continue second rolling until mixture has been thoroughly compacted.

F. Finish Rolling: Perform finish rolling while mixture is still warm enough for removal of roller marks. Continue rolling until roller marks are eliminated and course has attained maximum density.

G. Patching: Remove and replace paving areas mixed with foreign materials and defective areas. Cut out such areas and fill with fresh, hot asphalt concrete. Compact by rolling to maximum surface density and smoothness.

H. Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened. Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.

3.05 FIELD QUALITY CONTROL

A. Independent Testing Laboratory, selected and paid by the Owner, shall be retained to perform construction testing of in-place asphalt concrete courses for compliance with requirements for density. Testing shall be in accordance with ASTM D-2922 and NMDOT Standard Specifications, Latest Edition.

B. Grade Control: Establish and maintain required lines and elevations.

C. Surface Smoothness: Testing shall be performed on the finished surface of each asphalt concrete course for smoothness, using 10' - 0" straightedge applied parallel with, and at right angles to centerline of paved area. The results of these tests shall be made available to the owner upon request. Surfaces will not be acceptable if exceeding following tolerances for smoothness:

   Subgrade: 1/2"
   Wearing Course Surface: 3/16"

D. Check surface areas at intervals necessary to eliminate ponding areas. Remove and replace unacceptable paving as directed by Owner.

END OF SECTION

SECTION 32 1300

CONCRETE PAVEMENT, CURB AND SIDEWALK

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes all portland concrete pavement outside the building limits, including but not limited to:

1. Driveways and roadways
2. Parking lots
3. Curbs and gutters
4. Sidewalks

B. For concrete located within the building limits: refer to Section 03 0100 thru 03 2000 – Cast-In-Place Concrete

1.02 REFERENCE STANDARDS

A. American Society of Testing Materials (ASTM)

1. A82 - Standard Specification for Steel Wire, Plain, for Concrete Reinforcement
2. A185 - Standard Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement
3. A615/A615M - Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
4. C33 - Standard Specification for Concrete Aggregates
5. C94 - Standard Specification for Ready-Mixed Concrete
6. C150 - Standard Specification for Portland Cement
7. C171 - Standard Specification for Sheet Materials for Curing Concrete
8. C260 - Standard Specification for Air-Entraining Admixtures for Concrete
9. C309 - Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
10. C494/C494M - Standard Specification for Chemical Admixtures for Concrete
11. C979 - Standard Specification for Pigments for Integrally Colored Concrete
12. C1116 - Standard Specification for Fiber-Reinforced Concrete and Shotcrete
13. D1751 - Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
14. D1752 - Standard Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction
15. D3405 - Standard Specification for Joint Sealants, Hot-Applied, for Concrete and Asphalt Pavements
16. D5249 - Standard Specification for Backer Material for Use with Cold- and Hot-Applied Joint Sealants in Portland-Cement Concrete and Asphalt Joints
17. D5893 - Standard Specification for Cold Applied, Single Component, Chemically Curing Silicone Joint Sealant for Portland Cement Concrete Pavements

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B. American Concrete Institute (ACI)

1. 301R-99 – Specifications for Structural Concrete
2. 304R – Placing and Handling Concrete, etc.
3. 309R-96 – Guide for Consolidating of Concrete
4. 330.1 – Standard Specifications for Plain Concrete Parking Lots
5. 330R-92 – Guide for Design & Construction of Concrete Parking Lots
6. 211.1R-91 – Standard Practice for Selecting Proportions for Normal, Heavyweight and Mass Concrete

C. American Association of State Highway and Transportation Officials (AASHTO)

1. M182 – Standard Specifications for Burlap Cloth made from Jute for Kenaf
2. M153 – Standard Specifications for Preformed Sponge Rubber and Cork Expansion Joint Filler

D. ADAABAAG Americans with Disabilities Act

1. Architectural Barriers Act Accessibility Guidelines 36 CFT Part 1191

1.03 SUBMITTALS

A. Mix Design: For each concrete mix to be utilized.

B. Material certificates and test reports.

C. The General Contractor and the Subcontractor shall execute the Conformance Submittal(s) at the end of this section.

PART 2 - PRODUCTS

2.01 STEEL REINFORCEMENT

A. The type of steel reinforcement shall be as shown on the drawings.

1. Plain-Steel Welded Wire Fabric: ASTM A 185, 6inches x 6inches #10 mesh fabricated from steel wire into flat sheets;
2. Reinforcement Bars: ASTM A 615/A 615M, Grade 40, deformed;
3. Plain Steel Wire: ASTM A 82, as drawn; and,
4. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening steel reinforcement. Manufacture bar supports according to CRSI's Manual of Standard Practice.
5. Diamond Dowels: ¼" x 4 ½" Diamond Dowels by PNA

2.02 CONCRETE MATERIALS

A. Portland Cement: ASTM C 150, Type I, II or III.

B. Aggregate: ASTM C 33. Combined aggregate gradation for concrete pavement and other designated concrete shall be 8% - 18% for large top size aggregates (1½") or 8% - 22% for smaller top size aggregates (1" or ¾") retained on each sieve below the top size and above the No. 100 sieve. Concrete pavements shall have a maximum aggregate size of 1½".

C. Water/Ready Mix Concrete: ASTM C 94.

D. Admixtures: Certified by manufacturer to contain not more than 0.1 % water-soluble chloride ions by mass of cement and to be compatible with other admixtures, as follows:

1. Air-Entraining Admixture: ASTM C 260;
2. Water-Reducing Admixture: ASTM C 494, Type A;

3. Water-Reducing and High-Range Admixture: ASTM C 494, Type F;
4. Water-Reducing and Accelerating Admixture: ASTM C 494, Type E; and,
5. Water-Reducing and Retarding Admixture: ASTM C 494, Type D.

E. Fly Ash: The use of fly ash, slag and bottom ash is prohibited.

F. Calcium Chloride: The use of calcium chloride or admixtures containing more than 0.05% chloride ions is prohibited.

G. Curing Materials:

1. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. dry;
2. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet;
3. Water: Potable;
4. Evaporation Retarder: Waterborne, monomolecular film forming, manufactured for application to fresh concrete;
5. Clear Solvent-Borne Liquid-Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B;
6. Clear Waterborne Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B;
7. White Waterborne Membrane-Forming Curing Compound: ASTM C 309, Type 2, Class B.

2.03 CONCRETE MIXES AND MIXING

A. Concrete Mixes: Prepare design mixes, proportioned according to ACI 211.1R-91 and ACI 304, with the following properties:

1. Compressive Strength (28 Days): 4,000 psi;
2. Slump Limit: maximum of 5 inches at time of placement for pavement, 2 inch maximum for curb and sidewalk;
3. Air Content: 5% to 8% for pavement, curb and sidewalk.

B. Coloring Agent: When required, add coloring agent to mix according to manufacturer's written instructions.

1. Expansion- and Isolation-Joint-Filler Strips: ASTM D 1751, asphalt-saturated cellulosic fiber, or ASTM D 1752, cork or self-expanding cork; and,
2. Coloring Agent: ASTM C 979, synthetic mineral-oxide pigments or colored water-reducing admixtures; color stable, nonfading, and resistant to lime and other alkalis.

C. Ready-Mixed Concrete: Comply with requirements and with ASTM C 94 and ASTM C 1116.

D. Project-Site Mixing: On-site mixing must be approved by the Owner. Comply with requirements and measure, batch, and mix concrete materials and concrete according to ASTM C 94. Mix concrete materials in appropriate drum-type batch machine mixer.

2.04 JOINTS, FILLERS, AND SEALANTS

A. See Architectural Site Plan, Site Plan Details, and Specifications for details.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Surface Preparation: Proof roll prepared subbase, per Section 31.00.00 and the geotechnical report-Earthwork and remove loose material from surface.

B. Forms: Set, brace, and secure edge forms, bulkheads, and intermediate screed guides for pavement to required lines, grades, and elevations, per Section 02010, Project Survey and Layout.

1. Maintain sufficient quantity of forms to allow continuance of work so that forms remain in place a minimum of 24 hours after concrete placement;
2. Forms shall be cleaned and casted with form release agent thoroughly after each use and before concrete is placed; and,
3. Flexible or curved forms shall be used on curves. Forms shall be of full depth of the concrete and of a strength when staked, sufficient to resist the presence of the concrete and the loads resulting from the finish operations without springing, setting or losing their shape.

C. Reinforcement: Accurately position and support reinforcement, and secure against displacement. Set wire ties with ends directly into concrete.

1. Install welded wire fabric in lengths as long as practicable; lap at least one full mesh, and lace splices with wire; and,
2. Support reinforcing steel on wire chairs to ensure that wire stays mid-depth of sidewalk section during concrete pour.

D. Joints: Construct pre-molded expansion and contraction joints, tied construction joints, control joints, thickened edge expansion joints, isolation joints, and construction joints, straight with face perpendicular to concrete surface. Construct transverse joints perpendicular to centerline unless otherwise detailed.

1. Expansion joints and Contraction joints: Pre-molded as indicated on the drawings;
   a. Provide joint filler for the entire depth of the slab section and not less than 1inch below finished surface so as to allow for joint sealer.
   b. Provide thickened edge expansion joint as indicated on the drawings.
   c. Provide 1/2 inch contraction joints for curb and gutter at 10 feet on center.
   d. Provide 1/2 inch expansion joints for curb and gutter and sidewalk at 100 feet on center.
2. Tied construction joints: As indicated on drawings;
3. Control joints: Depth shall be equal to ¼ of the concrete thickness or 1 inch, whichever is deeper. For sidewalks, control joint spacing shall be equal to the sidewalk width. For concrete pavement, control joint spacing shall be placed as shown on the drawings, no greater than 30 times the slab thickness on center either way;
   a. Form tooled joints in fresh concrete by grooving top portion with recommended tool and finishing edges with jointer.
   b. Form sawed joints using powered saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut joints into hardened concrete within 24 hours of the concrete placement and as soon as surface will not be torn, abraded, or otherwise damaged by cutting action.
4. Construction Joints: Place construction joints at end of placements and at locations where placement operations are stopped for period of more than ½ hour, except where such placements terminate at expansion joints. Provide ¼" x 4½" Diamond Dowels by PNA at 24" on center or as shown on the drawings;
5. Isolation Joints: Locate isolation joints as indicated on the drawings. Provide premolded joint filler for catch basins, manholes, inlets, structures, walks, light pole bases and other fixed objects;
6. Joint Fillers: Extend joint fillers full-width and depth of joint, and not less than ½inch or more than 1inch below finished surface where joint sealer is indicated. Furnish joint fillers in one-

piece lengths for full width being placed, wherever possible. Where more than one length is required, lace or clip joint filler sections together; and,

7. Joint Sealants: All joints shall be sealed with approved exterior pavement joint sealants and shall be installed per manufacturer's recommendations.

E. Concrete Placement: Comply with recommendations in ACI 304R for measuring, mixing, transporting, and placing concrete. Place concrete in a continuous operation within planned joints or sections.

1. Moisten subbase to provide a uniform dampened condition at time concrete is placed;
2. Consolidate concrete by mechanical vibrating equipment supplemented by hand-spading, rodding, or tamping according to recommendations in ACI 309R;
3. Screed and initial-float concrete surfaces with darby or bull float before excess moisture or bleed water appears on the surface;
4. Protect concrete from cold or hot weather during mixing, placing, and curing; and,
5. All concrete walks and aprons shall be a minimum of 4 inches thick as shown on the drawings, with a turned down edge as detailed.

F. Evaporation Retarder: Apply to concrete surfaces if hot, dry, or windy conditions exist. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete, but before float finishing.

G. Pavement Tolerances: Comply with tolerances in ACI 330.1, Specification for Plain Concrete Parking Lots.

3.02 FINISHES AND CURING

A. All exterior concrete shall receive a medium broom finish.

B. Curing: Begin curing after finishing concrete, but not before free water has disappeared from concrete surface. Cure concrete by one or a combination of the following methods:

1. Moisture cure concrete by water, continuous fog spray, continuously wet absorptive cover, or by moisture-retaining-cover curing. Keep surfaces continuously moist for not less than 7 days; and,
2. Curing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating and repair damage during curing period.

C. All exterior concrete surfaces shall receive one coat of exterior sealer.

3.03 REPAIRS AND PROTECTION

A. Remove and replace concrete pavement that is broken, damaged, or defective, or does not meet requirements in this Section.

B. Protect concrete from damage. Provide adequate traffic control to prevent traffic from pavement for at least 14 days after placement.

C. Maintain concrete pavement free of stains, discoloration, dirt, and other foreign material. Sweep concrete pavement not more than 2 days before date scheduled for substantial completion inspections.

3.04 QUALITY ASSURANCE

A. Manufacturer Qualifications: Manufacturer of ready-mixed concrete products complying with ASTM C 94 requirements for production facilities and equipment.

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B. ACI Publications: Comply with ACI 301R-99 and ACI330R-92, unless modified by the requirements of the Contract Documents.

C. The owner shall provide and pay for testing services. A slump test and air test shall be performed for each load delivered. Four standard test cylinders shall be taken for each 55 cubic yards of concrete or each days pour, whichever is more frequent. Two cylinders shall be broken at 7 days and two cylinders shall be broken at 28 days.

END OF SECTION

SECTION 323113 - CHAIN LINK FENCES AND GATES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:
   1. Chain-Link Fences: Industrial

B. Related Sections include the following:

   1. Division 03 Section Cast-in-Place Concrete for concrete post concrete fill.

1.3 PERFORMANCE REQUIREMENTS

A. Structural Performance: Provide chain-link fences and gates capable of withstanding the effects of gravity loads and the following loads and stresses within limits and under conditions indicated:

   1. Minimum Post Size and Maximum Spacing for Wind Velocity Pressure: Determine based on mesh size and pattern specified, and on the following minimum design wind pressures and according to CLFMI WLG 2445:

      a. Wind Speed: 90 mph
      b. Fence Height: 6 feet
      c. Line Post Group: IA, ASTM F 1043, Schedule 40 steel pipe
      d. Wind Exposure Category: C

B. Lightning Protection System: Maximum grounding-resistance value of 25 ohms under normal dry conditions.

1.4 SUBMITTALS

A. Product Data: Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for chain-link fences and gates.

   1. Fence and gate posts, rails, and fittings.
   2. Chain-link fabric, reinforcements, and attachments.

B. Shop Drawings: Show locations of fences, gates, posts, rails, tension wires, details of extended posts, extension arms, gate swing, or other operation, hardware, and accessories. Indicate

materials, dimensions, sizes, weights, and finishes of components. Include plans, sections, details of post anchorage, attachment, bracing, and other required installation and operational clearances.

C. Qualification Data: For Installer.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer who has completed chain-link fences and gates similar in material, design, and extent to those indicated for this Project and whose work has resulted in construction with a record of successful in-service performance.

B. Pre-installation Conference: Conduct conference at Project site to comply with requirements in Division 01 Section "Project Management and Coordination."

1.6 PROJECT CONDITIONS

A. Field Measurements: Verify layout information for chain-link fences and gates shown on Drawings in relation to property survey and existing structures. Verify dimensions by field measurements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 CHAIN-LINK FENCE FABRIC

A. General: Height as indicated on drawings. Provide fabric in one-piece heights measured between top and bottom of outer edge of selvage knuckle or twist. Comply with ASTM A 392, CLFMI CLF 2445, and requirements indicated below:

1. Steel Wire Fabric: Metallic coated wire with a diameter of 0.148 inch

    a. Mesh Size: 2 inches
    b. Weight of Metallic (Zinc) Coating: ASTM A 392, Type II, Class 1, 1.2 oz./sq. ft. with zinc coating applied before weaving.
    c. Weight of Zn-5-Al-MM Aluminum-Mischmetal Alloy Coating: ASTM F 1345, Type III, Class 1, 0.60 oz./sq. ft. 2, 1.0 oz./sq. ft.
    d. Coat selvage ends of fabric that is metallic coated before the weaving process with manufacturer's standard clear protective coating.

2.3 INDUSTRIAL FENCE FRAMING

A. Posts and Rails: Comply with ASTM F 1043 for framing, ASTM F 1083 for Group IC round pipe, and the following:

1. Group: IA, round steel pipe, Schedule 40
2. Fence Height: As indicated in drawings
3. Strength Requirement: Heavy industrial according to ASTM F 1043.
4. Post Diameter and Thickness: According to ASTM F 1043 ASTM F 1083.

    a. Top Rail: 1.66 inches
    b. Line Post: 4' HT fence - 1.875 by 1.63 inches / 6' HT fence – 2.375 by 2.23 inches
    c. End, Corner and Pull Post: 3.5 by 1.5 inches
    d. Swing Gate Post: According to ASTM F 900 2.375-inch diameter, 3.11-lb/ft. weight 4-inch diameter, 8.65-lb/ft.
    e. Horizontal-Slide Gate Post: According to ASTM F 1184.

        1) Openings up to 12 Feet: Steel post, 2.875-inch diameter, and 4.64-lb/ft. weight.
        2) Openings Wider Than 12 Feet : Steel post, 4-inch diameter, and 8.65-lb/ft. weight.
        3) Guide posts for Class 1 horizontal-slide gates equal the gate post height, 1 size smaller, but weight is not less than 3.11 lb/ft.; installed adjacent to gate post to permit gate to slide in space between.

5. Coating for Steel Framing:

    a. Metallic Coating:

        1) Type A, consisting of not less than minimum 2.0-oz./sq. ft. average zinc coating per ASTM A 123/A 123M or 4.0-oz./sq. ft. zinc coating per ASTM A 653/A 653M.

2.4 TENSION WIRE

A. General: Provide horizontal tension wire at the following locations:

1. Location: Extended along bottom of fence fabric.
2. Location: Extended along top of barbed wire arms and top of fence fabric for supporting barbed tape.

B. Metallic-Coated Steel Wire: 0.177-inch- diameter, marcelled tension wire complying with ASTM A 817, ASTM A 824, and the following:

1. Metallic Coating: Type II, zinc coated (galvanized) by hot-dip process, with the following minimum coating weight:

    a. Class 1: Not less than 0.8 oz./sq. ft. of uncoated wire surface.
    b. Matching chain-link fabric coating weight.

2.5 INDUSTRIAL SWING GATES

A. General: Comply with ASTM F 900 for single and double swing gate types.

1. Metal Pipe and Tubing: Galvanized steel. Comply with ASTM F 1043 and ASTM F 1083 for materials and protective coatings.

B. Frames and Bracing: Fabricate members from galvanized steel tubing with outside dimension and weight according to ASTM F 900 and the following:

1. Gate Fabric Height: 2 inches less than adjacent fence height
2. Leaf Width:
3. Frame Members:

a. Tubular: 1.90 inches round

C. Frame Corner Construction:

1. Welded and 5/16-inch- diameter, adjustable truss rods for panels 5 feet wide or wider.

D. Extended Gate Posts and Frame Members: Extend gate posts and frame end members above top of chain-link fabric at both ends of gate frame 12 inches as required to attach barbed wire assemblies.

2.6 FITTINGS

A. General: Comply with ASTM F 626.

2.7 BARBED WIRE

A. Zinc-Coated Steel Barbed Wire: Comply with ASTM A 121, Standard Chain-Link Fence grade for the following two-strand barbed wire:

1. Standard Size and Construction: 0.099-inch- diameter line wire with 0.080-inch diameter, 2-point round barbs spaced not more than 4 inches o.c.

2.8 GROUT AND ANCHORING CEMENT

A. Nonshrink, Nonmetallic Grout: Premixed, factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107. Provide grout, recommended in writing by manufacturer, for exterior applications.

2.9 FENCE GROUNDING

A. Conductors: Bare, solid wire for No. 6 AWG and smaller; stranded wire for No. 4 AWG and larger.

1. Material above Finished Grade: Copper
2. Material on or below Finished Grade: Copper.
3. Bonding Jumpers: Braided copper tape, 1 inch wide, woven of No. 30 AWG bare copper wire, terminated with copper ferrules.

B. Connectors and Grounding Rods: Comply with UL 467.

1. Connectors for Below-Grade Use: Exothermic welded type.
2. Grounding Rods: Copper-clad steel.

a. Size: 5/8 by 96 inches.

2.10 All fencing, gates and backstops for baseball field, softball field, batting gates, soccer field and tennis courts shall be in compliance with details shown on the plans.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for site clearing, earthwork, pavement work, and other conditions affecting performance.

1. Do not begin installation before final grading is completed, unless otherwise permitted by Architect.
2. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Stake locations of fence lines, gates, and terminal posts. Do not exceed intervals of 500 feet or line of sight between stakes. Indicate locations of utilities, lawn sprinkler system, underground structures, benchmarks, and property monuments.

3.3 INSTALLATION, GENERAL

A. Install chain-link fencing to comply with ASTM F 567 and more stringent requirements specified.

1. Install fencing on established boundary lines inside property line.

3.4 CHAIN-LINK FENCE INSTALLATION

A. Post Excavation: Drill or hand-excavate holes for posts to diameters and spacings indicated, in firm, undisturbed soil.

B. Post Setting: Set posts in concrete at indicated spacing into firm, undisturbed soil.

1. Verify that posts are set plumb, aligned, and at correct height and spacing, and hold in position during setting with concrete or mechanical devices.
2. Concrete Fill: Place concrete around posts to dimensions indicated and vibrate or tamp for consolidation. Protect aboveground portion of posts from concrete splatter.

a. Exposed Concrete: Extend 2 inches above grade; shape and smooth to shed water.

C. Terminal Posts: Locate terminal end, corner, and gate posts per ASTM F 567 and terminal pull posts at changes in horizontal or vertical alignment of 30 degrees or more.

D. Line Posts: Space line posts uniformly at 8 feet o.c.

E. Post Bracing and Intermediate Rails: Install according to ASTM F 567, maintaining plumb position and alignment of fencing. Install braces at end and gate posts and at both sides of corner and pull posts.

1. Locate horizontal braces at midheight of fabric 6 feet or higher, on fences with top rail and at 2/3 fabric height on fences without top rail. Install so posts are plumb when diagonal rod is under proper tension.

F. Tension Wire: Install according to ASTM F 567, maintaining plumb position and alignment of fencing. Pull wire taut, without sags. Fasten fabric to tension wire with 0.120-inch- diameter hog rings of same material and finish as fabric wire, spaced a maximum of 24 inches o.c. Install tension wire in locations indicated before stretching fabric.

1. Bottom Tension Wire: Install tension wire within 6 inches of bottom of fabric and tie to each post with not less than same diameter and type of wire.

G. Top Rail: Install according to ASTM F 567, maintaining plumb position and alignment of fencing. Run rail continuously through line post caps, bending to radius for curved runs and terminating into rail end attached to posts or post caps fabricated to receive rail at terminal posts. Provide expansion couplings as recommended in writing by fencing manufacturer.

H. Chain-Link Fabric: Apply fabric to outside of enclosing framework. Leave 1 inch between finish grade or surface and bottom selvage, unless otherwise indicated. Pull fabric taut and tie to posts, rails, and tension wires. Anchor to framework so fabric remains under tension after pulling force is released.

I. Tension or Stretcher Bars: Thread through fabric and secure to end, corner, pull, and gate posts with tension bands spaced not more than 15 inches o.c.

J. Tie Wires: Use wire of proper length to firmly secure fabric to line posts and rails. Attach wire at 1 end to chain-link fabric, wrap wire around post a minimum of 180 degrees, and attach other end to chain-link fabric per ASTM F 626. Bend ends of wire to minimize hazard to individuals and clothing.

1. Maximum Spacing: Tie fabric to line posts and top rail at 12 inches o.c. and to braces at 24 inches o.c.

K. Fasteners: Install nuts for tension bands and carriage bolts on the side of the fence opposite the fabric side. Peen ends of bolts or score threads to prevent removal of nuts.

L. Barbed Wire: Install barbed wire uniformly spaced angled toward security side of fence. Pull wire taut and install securely to extension arms and secure to end post or terminal arms.

M. Barbed Tape: Install barbed tape uniformly in configurations indicated and fasten securely to prevent movement or displacement.

N. Tennis Court Fencing: Construct tennis court fence according to ASTM F 969.

3.5 GROUNDING AND BONDING

A. Fence Grounding: Install at maximum intervals of 1500 feet except as follows:

1. Fences within 100 Feet of Buildings, Structures, Walkways, and Roadways: Ground at maximum intervals of 750 feet

a. Gates and Other Fence Openings: Ground fence on each side of opening.

1) Bond metal gates to gate posts.
2) Bond across openings, with and without gates, except openings indicated as intentional fence discontinuities. Use No. 2 AWG wire and bury it at least 18 inches below finished grade.

B. Protection at Crossings of Overhead Electrical Power Lines: Ground fence at location of crossing and at a maximum distance of 150 feet on each side of crossing.

C. Fences Enclosing Electrical Power Distribution Equipment: Ground as required by IEEE C2, unless otherwise indicated.

D. Grounding Method: At each grounding location, drive a grounding rod vertically until the top is 6 inches below finished grade. Connect rod to fence with No. 6 AWG conductor. Connect conductor to each fence component at the grounding location, including the following:

1. Each Barbed Wire Strand. Make grounding connections to barbed wire with wire-to-wire connectors designed for this purpose.
2. Each Barbed Tape Coil: Make grounding connections to barbed tape with connectors designed for this purpose.

E. Bonding Method for Gates: Connect bonding jumper between gate post and gate frame.

F. Connections: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.

1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
2. Make connections with clean, bare metal at points of contact.
3. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.
4. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
5. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

G. Bonding to Lightning Protection System: If fence terminates at lightning-protected building or structure, ground the fence and bond the fence grounding conductor to lightning protection down conductor or lightning protection grounding conductor complying with NFPA 780.

3.6 ADJUSTING

A. Gate: Adjust gate to operate smoothly, easily, and quietly, free of binding, warp, excessive deflection, distortion, nonalignment, misplacement, disruption, or malfunction, throughout entire operational range. Confirm that latches and locks engage accurately and securely without forcing or binding.

END OF SECTION 323113

SECTION 328400 - LANDSCAPE IRRIGATION SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. The work consists of installing a complete underground irrigation system as shown on the Drawings and as specified hereafter. The Contractor shall furnish all labor, equipment, materials and permits necessary for the completion of the system, unless otherwise specified to be furnished by others. Unless otherwise specified or indicated on the Drawings, the construction of the irrigation system shall include the furnishing, installing and testing of all components pertinent to the system. The Contractor shall perform all trenching, excavating, boring, backfilling, compacting, concrete work, electrical work, welding, and any other work necessary for the completion of the irrigation system.

1.2 SITE INVESTIGATION

A. The Contractor shall examine related work and surfaces before starting the work of this section. The Contractor shall report to the Owner's Representative, in writing, conditions which will prevent the proper execution of irrigation installation. Deviations from Drawings and Specifications shall be executed only with the express permission of the Owner's Representative and at no cost to the Owner. If inadequacies or inappropriate design are found on the Drawings, they shall be promptly brought to the attention of the Owner's Representative in writing before proceeding with installation of the system.

1.3 CODES, RULES AND SAFETY ORDERS

A. All work and materials shall be in full accordance with the latest local rules and regulations of safety.

1.4 PROTECTION

A. The Contractor shall furnish and maintain all warning signs, shoring, barricades, red lanterns, and other protection devices, as required by the Safety Orders of the Division of Industrial Safety and local ordinances.

1.5 DEVIATIONS OF LAYOUT

A. Reasonable changes in the location of piping, valves or other irrigation components shown on the Drawings will be considered prior to installation. Deviations from specified locations must be approved by the Owner's Representative prior to installation. Any changes in location of irrigation components shall be effected at no cost to the Owner.

1.6 COORDINATION

A. The Contractor shall coordinate and cooperate with other contractors on site to ensure rapid and efficient completion of all contracted work.

1.7 SUBMITTALS

A. The Contractor shall prepare submittals providing manufacturer's specifications and product information on the following components:

Manual and automatic valves	Heads and emitters		Enclosures
Backflow preventer	Valve boxes	Drains	
24 Volt wire	Wire splicing materials		Controller
Piping and tubing	PVC fittings	Filters	
Joint materials	Detectable line marking tape		Grounding wire
PVC primer and cement	Threaded joint sealant or tape		Grounding rods
Quick couplers	Swing joints		

B. Each set of submittals shall be bound or provided electronically in PDF format, and shall be clearly labeled with the project name and date.

C. The Contractor shall not proceed with the irrigation system work until receiving approval of the irrigation submittals from the Owner's Representative.

1.8 AS-BUILTS

A. The Contractor shall provide and keep up to date a complete set of "As-Builts" which shall be corrected daily to show all changes in the location of heads, controllers, backflow preventers, valves, drains, meters, points of connection, pull boxes and wire splice boxes, pipe and wire routing and other changes that may have been made from the original Drawings and Specifications. All gate valves, manual drains, wire splice and automatic and manual valve locations shall be shown with actual measurements to reference points so they may be easily located in the field.

B. At the time of final acceptance, the Contractor shall furnish one electronic copy (on CD) and one paper copy of "As-Builts" prepared by a qualified draftsperson in AutoCAD format, showing the entire completed system as actually installed. This is the responsibility of the Contractor and shall not be construed to be the responsibility of any other party. This drawing shall be accurate and to scale. The symbols for valves, heads, and piping and other components shall be the same as originally shown on the Drawings. The legend shall be modified to designate any "record" changes. This "As-Built" shall be drawn on a project base sheet provided by the Owner's Representative. The final drawings shall be dated and clearly labeled "AS-BUILT".

1.9 CONTROLLER CHART

A. The Contractor shall provide two controller charts for each controller. Chart shall show the area covered by each automatic valve station on the controller with a different color used to show the area of coverage for each valve. Chart shall be a reduced drawing of the actual "As-Built" system. The size of the chart shall be the maximum size that the controller door will allow. If controller sequence is not legible when the drawing is reduced, drawing shall be enlarged to a size that is readable.

B. When completed and approved, chart shall be laminated with minimum 20 mils thick sheets. Chart shall be completed and approved prior to final observation and acceptance of the irrigation system. Contractor shall install one chart in each controller enclosure and shall provide one chart for each controller to the Owner's Representative.

PART 2 - PRODUCTS

2.1 MATERIALS

A. All materials shall be new and without flaws or defects of any type and shall be the best of their class and kind. All materials shall have a minimum warranty of one year against material defects or defective workmanship.

B. All material shall be the brands and types noted on the Drawings or as specified herein, or approved equal (refer to Section 6.7 of the New Mexico Standard Specifications for Public Works Construction, 1979 Edition).

C. The irrigation system was designed around equipment manufactured by specific companies as a standard. Approved equal equipment by other manufacturers may be used only with the approval of the Owner's Representative. Request for approval of non-specified materials shall be submitted to the Owner's Representative a minimum of seven (7) days prior to the opening of bids. Submission of irrigation sprinkler heads for approval as equal shall only be considered if submitted heads match the precipitation rate, gallons per minute and spacing of specified sprinkler heads.

D. Irrigation components designated for use with recycled water shall be marked in accordance with the Uniform Plumbing Code.

2.3 PLASTIC PIPE AND FITTINGS

A. Plastic Pipe: Piping with a diameter of two inches (2") or less shall be Schedule 40 PVC and shall conform to ASTM D 1785. Piping with a diameter of two and one-half inches (2-1/2") or greater shall be Class 200 "O" ring gasket pipe, SDR 21 and shall conform to ASTM D 2241. All PVC pipe shall be continuously marked with identification of the manufacturer, type, class, and size, and shall be free of holes, foreign material, blisters, wrinkles, dents or sunburn.

B. PVC Fittings: Fittings on PVC lines shall be Schedule 40 PVC, Type 1, Cell Classification 12454 and shall comply with ASTM D 2466.

C. Threaded Nipples: All threaded PVC nipples shall be Schedule 80 molded PVC pipe. All galvanized nipples shall be Schedule 40 galvanized steel pipe.

2.4 VALVES AND VALVE BOXES

A. Valves: Valves for use in electrically controlled automatic control systems shall be diaphragm actuated and hydraulically operated solenoid valves as specified on the

Drawings.

B. Isolation valves shall be as specified on the Drawings.

C. Valve Boxes: Valve boxes shall be as noted on the Drawings. Valve box colors shall be as follows:
   1. Green: Turf areas (potable water)
   2. Tan: Gravel mulch areas (potable water)
   3. Purple: Reclaimed water

2.5 HEADS AND EMITTERS

A. Heads and emitters shall be as specified on the Drawings.

2.6 CONTROLLER

A. Controller shall be as specified on the Drawings.

2.7 BACKFLOW PREVENTER AND HEATED ENCLOSURE

A. The backflow prevention device and heated enclosure shall be as specified on the Drawings.

2.8 PRIMER, CEMENT AND THREADED JOINT SEALANT

A. Primer shall conform to ASTM F 656 and meet NSF. Cement shall be low VOC, NSF approved, and meet ASTM D 2564. Cement and primer shall be IPS Weld-On depending on size and schedule of pipe and fittings as follows:

Schedule 40 PVC Pipe and Fittings up to 6” Dia.:	P-68 Primer and 705 Cement
Schedule 80 PVC Pipe and Fittings up to 4” Dia.:	P-70 Primer and 705 Cement
Schedule 80 PVC Pipe and Fittings larger than 4” Dia.:	P-70 Primer and 711 Cement

B. All threaded connections between metal to metal, PVC to metal**,** and PVC to PVC shall be made using Spears Blue 75 thread sealant or Polytetrafluoroethylene (PTFE) thread seal tape. PTFE thread seal tape shall comply with MIL-T-27730A Specifications shall have a minimum thickness of 3.5 mils and shall be 99% pure PTFE. Thread sealing compound shall not be used on threaded connections between sprinkler and nipple or bubbler and nipple. Thread sealant or PTFE tape shall be used in accordance with manufacturer’s installation instructions.

C. All “O” ring gasket and pipe spigot ends shall be lubricated using the lubricant recommended or supplied by the pipe manufacturer. If the pipe manufacturer does not provide a lubricant for the pipe, use IPS Weld-on EZ Flush pipe lubricant, NSF approved.

2.9 WIRE

A. Wire for the 120 volt wiring shall be solid copper (or stranded copper in larger wire sizes), underground feeder for direct burial and PVC insulated. Size of wire shall be #12 AWG.

B. Wire for the 24 volt wiring shall be solid copper wire, PVC insulated, UL approved underground feeder wire for direct burial in ground. Common wires shall be #12, white, except as noted on Drawings. The control wires shall be #14 of any color other than white unless otherwise indicated on Drawings. The wire shall be supplied in either 500' or 2,500' rolls.

C. Wire Splicing Materials: All wire splices shall be made water-tight using 3M DBR/Y direct bury splice kit or approved equal.

D. Grounding wire, ground rods and wire clamps for controllers shall be as specified by the controller manufacturer.

E. Control wires shall be marked with the associated valve number with E-Z Coder WDR or equal wire marking tape at each valve, at the controller and at wire splices.

2.10 DETECTABLE LINE MARKING TAPE

A. Detectable line marking tape for irrigation main and lateral lines shall be manufactured by T.A. Christy Enterprises or approved equal and shall consist of a minimum 5.0 mil (0.0050") overall thickness; five-ply composition; ultra high molecular weight; 100% virgin polyethylene; acid, alkaline, and corrosion resistant.

B. The tape width shall be a minimum of 6".

C. Elongation properties shall be in accordance with ASTM D882-80A and shall be less than 150% at break.

D. Tensile strength shall be in accordance with ASTM D882-80A and shall be not less than 7800 PSI.

E. The tape shall have a minimum 20 gauge (0.0020") solid aluminum foil core, adhered to a 2.55 mil (0.00255") polyethylene backing.

F. Tape color and legend combination shall be in accordance with APWA requirements. For irrigation lines with potable water supply, the color shall be blue and the legend shall read "CAUTION: IRRIGATION LINE BURIED BELOW". For irrigation lines with non-potable water supply, the color shall be purple and the legend shall read "CAUTION: RECYCLED/RECLAIMED WATER LINE BURIED BELOW".

2.11 OTHER MISCELLANEOUS FITTINGS AND MATERIALS

A. All other miscellaneous fittings and materials shall be as specified on the Drawings.

PART 3 - EXECUTION

3.1 GENERAL

A. This section includes installation specifications for all items installed as a part of the irrigation system. Certain construction procedures or minor equipment installation procedures that are necessary for the proper installation of the system may have been omitted from these specifications. In any case, Contractor shall install all materials and equipment in a neat and workmanlike manner according to manufacturer's recommendations and specifications, local and state codes, as shown on the Drawings and as specified herein.

3.2 PRODUCT HANDLING

A. The Contractor shall be responsible for correct procedures in loading, unloading, staking, transporting and handling all materials to be used in the system. The Contractor shall avoid rough handling which could affect the useful life of equipment. Pipe shall be handled in accordance with the manufacturer's recommendations on loading, unloading and storage.

3.3 POINT OF CONNECTION

A. Existing water main line locations shown on the Drawings are schematic. It shall be the Contractor’s responsibility to pot hole and field check to determine actual locations as an incidental requisite to the construction contract.

B. The proposed controller location indicated on the Drawings is approximate. Actual location of the controller shall be determined by Owner’s Representative in the field.

C. Where connections to existing pipe or stub out is required, the Contractor shall make necessary adjustments should pipe or stub out not be located exactly as shown, at no additional cost to the Owner.

3.4 STATIC PRESSURE TEST

A. The design pressure of the irrigation system is shown on the Drawings. Prior to start of construction of the irrigation system, the Contractor shall, in the presence of the Owner’s Representative, provide a gauged test of available static pressure at the point of connection. In the event that the actual static pressure is significantly different (plus or minus 10 psi) than the design static pressure, the Contractor shall not proceed with the work until receiving written direction from the Owner’s Representative.

3.5 EXCAVATION AND TRENCHING

A. The Contractor shall stake the location of each run of pipe and all sprinkler heads and valves prior to trenching. Each run of the system shall be approved by the Owner’s Representative prior to installation.

B. Excavation and trenching for pipe lines shall be a true and straight line with the trench banks as nearly vertical as practical. The width of the trenches shall not be greater than

necessary to permit proper joining, tamping, backfilling, bedding or any other installation procedures that may be necessary. Trench widths shall be wide enough to provide a minimum horizontal and vertical separation of 4" between pipes in the same trench.

C. In areas where trees are present, trench lines shall be adjusted on the site to eliminate any damage to tree roots.

D. Trench depths shall be sufficient to provide the specified pipe cover as described elsewhere in these Specifications or as noted on the Drawings. In rocky areas the trench depth and width shall be increased as needed to provide for a minimum of 6"of pipe bedding at bottom and sides of pipe.

E. Depth of Bury: Minimum cover over mainline and lateral piping shall be as noted on the Drawings.

3.6 PIPE AND FITTINGS INSTALLATION

A. Installation of plastic pipe and fittings shall be in accordance with ASTM D 2774, the manufacturer's recommendations and the procedures described in these Specifications.

B. Caution shall be exercised by the Contractor in handling, loading, unloading, and storing of PVC pipe and fittings. All PVC pipe shall be stored and transported in a vehicle with a bed long enough to allow the pipe to lie flat without subjecting it to undue bending or concentrated external load at any point. Pipe shall be protected from damage by exposure to sunlight. Any section of pipe that has been dented or damaged or in any other way found to be defective, either before or after laying shall be replaced with sound pipe at no cost to the Owner.

C. Before installation, the inside of the pipe shall be cleaned of all dirt and foreign matter and shall be kept in a clean condition during and after laying of pipe. When work is not in progress, open ends of pipe and fittings shall be secured closed so that no trench water, earth or other foreign substances will enter the pipe or fittings. Where pipe ends are left for future expansion or connections, they shall be valved and capped as directed on the Drawings.

D. All PVC pipe and fittings shall be assembled to permit the pipe or fittings to be jointed at the true parallel position of the fittings. Placement of pipe which cause excessive bending and stress on pipe and fittings will not be permitted. No excess piping or fittings shall be permitted in the installation of the system, as this may increase pressure loss or potential for blockage.

E. Before installing the pipe, all rocks over 1 inch diameter, rubbish and debris shall be removed from the trenches. If the adjacent soil is rocky, the trenches shall be bedded and filled with clean dirt or sand to provide a minimum of 6" clearance between the pipe and the native soil. Material used for pipe bedding and trench filling shall be approved by the Owner's Representative. The full length of each section of the pipe shall rest solidly upon the pipe bed, with recesses excavated to accommodate bells, joints and couplings.

F. Pipe shall not be laid in water or when trench or weather conditions are unsuitable for the work. Any water which may be encountered or may accumulate in the trenches or excavation shall be pumped out or otherwise removed as necessary to keep the bottom of the trench or excavation free and clear of water during the progress of the work. Pipe shall not be laid when the temperature is 32 degrees F or below.

G. PVC pipe will expand or contract at the rate of +/- 3/8" per 100' per 10 degrees F change of temperature. Therefore, the pipe shall be installed in a manner to provide for expansion and contraction as recommended by the manufacturer.

H. The minimum horizontal and vertical clearance between lines in the same trench shall be 4".

I. After all piping, risers, valves, thrust blocks, etc., have been installed and partially backfilled as specified in other parts of these Specifications, the control valve shall be opened and a full head of water used to flush out the system. Caution shall be observed to provide for release of any entrapped air in the system. After the system is thoroughly flushed, risers shall be capped and the system pressure tested in accordance with the testing section of these Specifications. At the conclusion of the pressure test, the heads shall be installed and the backfill operation completed.

3.7 SOLVENT WELDING PROCEDURE

A. All solvent weld joints shall be made in accordance with the solvent manufacturer's recommendations and ASTM D 2855.

B. PVC plastic pipe shall be squarely cut utilizing a miter box mounted hacksaw or PVC specialty saw with a blade of 18 or 24 teeth per inch.

C. Interior and exterior burrs shall be removed and the exterior shall be beveled to produce a 10-15 degree bevel.

D. Thoroughly clean the mating pipe end and the fitting socket with a clean, dry cloth.

E. Using a properly sized applicator (approximately ½ the diameter of the pipe), apply a light coating of primer to the inside of the fitting socket, then apply a thin coat to the outside of the pipe end. Apply a second, light coat of primer to the inside of the fitting socket taking care to avoid puddling of primer in fitting.

F. Apply a uniform coat of cement to the outside of the pipe end with a properly sized applicator (approximately ½ the diameter of the pipe).

G. In like manner, apply a thin coating of cement to the inside of the fitting socket.

H. Re-apply a light coat of cement to the outside of the pipe end and quickly insert it into the fitting to the full depth of the fitting socket, while rotating the pipe or fitting approximately ¼ turn to ensure even distribution of cement.

I. Hold in position for approximately 30 seconds.

J. Wipe off any excess solvent cement that forms as a bead around the outer shoulder.

K. Contractor shall not use an excessive amount of solvent cement that could cause burrs or obstructions to form on the inside of the pipe joint.

L. Solvent weld joints shall be allowed to cure for minimum 24 hours before pressure is applied to the system.

3.8 BACKFILLING

A. Upon completion of a particular section of the irrigation system, and after sufficient time has elapsed for the curing of solvent weld joints, partial backfilling shall begin, leaving all joints, risers and connections exposed for visual inspection during the hydrostatic testing. Only upon successful completion of the hydrostatic test shall the backfill operation be completed for any one particular section.

B. All backfill material shall be subject to approval by the Owner's Representative. Backfill material shall be free from rock, large stones, brush, sod, frozen material or other unsuitable substances that may damage pipe or compromise compaction during the backfilling operations.

C. In the event that the material from the excavation or trenching is found to be unsuitable for use in backfill by the Owner's Representative, it shall be removed from the site and properly disposed of by the Contractor at his own expense. The Contractor shall then, at no cost to the Owner, arrange for, purchase, and furnish suitable backfill material consisting of earth, loam, sandy clay, sand or other approved materials free of large clods of earth or sharp stones and capable of attaining the same relative density of the surrounding ground.

D. In rocky areas, the trench depth shall be 6" below the normal trench depth to allow for 6" of suitable backfill as padding for the pipe. In like manner, there shall be minimum 6" of suitable backfill on all sides of the pipe as padding against rock in the wall of the trench.

E. All mainline and lateral piping shall have detectable line marking tape installed in the trench six (6") inches above the pipe. After pipe is placed in trench and the first 6" layer of backfill is placed and compacted, the detectable marking tape shall be placed continuously in all trenches prior to completion of backfill operations.

F. Backfill shall be placed in horizontal layers not exceeding 6" in depth and shall be thoroughly tamped, or water compacted to near original density or so that no settling will result. Backfill shall be placed to the original ground level. If settlement of trenches occurs within one (1) year from date of completion, it shall be the Contractor's responsibility to refill trenches and re-seed, re-sod or re-install landscape mulch in the repaired areas.

3.9 SADDLE TAPS

A. No saddle taps shall be permitted unless approved by the Owner's Representative.

3.10 THRUST BLOCKS

A. Concrete thrust blocks shall be provided where necessary to resist system pressure, including at all direction changes, size changes, valves and terminations or at any other points of the system that will result in an unbalanced thrust line for equipment 2-1/2" and larger and as indicated on the Drawings. Thrust blocks shall not obstruct the outlets of fittings which are intended for future connections. Thrust blocks shall be poured against undisturbed earth and in accordance with the Drawings.

3.11 SLEEVED CROSSING

A. Unless otherwise noted on the Drawings, all piping installed under sidewalks, roadways, parking lots, etc., shall be sleeved in a Class 200 PVC pipe two (2) sizes larger than the pipe to be sleeved. Wire shall be placed in a separate sleeve from that of the pipe crossing and shall be Class 200 PVC minimum 2" size, or larger as required to accommodate the quantity of wire to be sleeved. Ends of sleeves shall be sealed with duct tape after installation of wire or piping.

3.12 HEAD INSTALLATION (ROTORS AND POP UPS)

A. Heads shall be of the type and make specified and shall be installed as shown on the Drawings. Heads shall be installed with a 4" space between the edge of the head and curbs, walks, walls, driveways, building walls, etc. Heads shall be installed in the vertical position and backfilled and compacted to 80% modified Proctor.

B. Head spacing shall not exceed the spacing shown on the Drawings and shall be in the location and configuration as shown on the Drawings. Contractor shall verify turf area dimension while staking head location. Heads shall be spaced to achieve uniform coverage.

C. After all piping and risers are in place and connected and before installation of the heads, all control valves for a given section shall be fully opened and a full head of water shall be used to flush out the system. If water pressure without the heads installed is not sufficient to provide adequate water flow from end risers, the Contractor shall cap off enough heads closest to the water source to provide adequate flushing of the end riser assemblies.

3.13 CONTROLLER INSTALLATION

A. The controller location is indicated on the Drawings. The Contractor shall familiarize himself with the requirements of making the power connections at the locations noted (120 volt supply to the controller) and shall include in his price for the-irrigation system, the cost to complete this portion of the work.

B. The controller shall be mounted and wired according to the manufacturer's recommended procedures and as specified herein and on the Drawings.

C. Unless otherwise indicated in the Drawings, the Contractor shall direct-wire the 120 volt power supply to the controller.

D. Remote control valves shall be connected to controller in the numerical sequences as shown on the Drawings or as directed by the Owner's Representative.

E. Controllers shall be grounded as specified by the manufacturer and as indicated on the Drawings.

3.14 AUTOMATIC CONTROL VALVE INSTALLATION

A. Automatic control valves shall be of the type and size indicated on the Drawings. Installation shall be according to these Specifications, the Drawings and the manufacturer's recommendations.

B. The valve boxes shall be of the size and type as shown on the Drawings.

C. Valve wire splices shall be waterproofed using 3M DBR/Y direct bury splice kit or approved equal. The Contractor shall provide a 36" wire expansion coil to facilitate raising splices to ground level without cutting wires.

3.15 24 VOLT CONTROL VALVE WIRING

A. Wire installation procedures shall conform to local codes.

B. The Contractor shall install the 24 volt control valve wiring in the same trench as the irrigation mainline. All wires shall be laid below the pipe. In no case shall the wire be laid on top of the pipe. The wires shall be laid loose in the trench and taped together at 10'-0" intervals. When trenches used for piping are not appropriate for routing wire, Contractor shall install wire in a separate trench at 18" bury depth.

C. Wire splices, other than at valve box locations, shall be kept to a minimum and if needed shall be made only at common splice points and placed in a wire splice box, Applied Engineering 9" round valve box with flush cover or equal. Wire splices shall be waterproofed using 3M DBR/Y direct bury splice kit or approved equal.

D. At control wire splices, the Contractor shall provide a 36" wire expansion coil to facilitate raising splices to ground level without cutting wires.

E. Continual wire shall be one color and in no case shall wires of different colors be spliced together.

F. All 24 volt wiring shall be installed in PVC conduit when inside a building. All 24 volt wiring installed on exterior building walls shall be installed in metal conduit.

3.16 120 VOLT CONTROLLER POWER WIRING

A. The Contractor shall familiarize himself with the work required to complete this portion of the installation. All 120 volt wiring shall be installed in accordance with local electrical codes. The 120 volt service shall consist of one (1) black and one (1) white wire. The neutral wire shall be bonded.

B. The 120 volt power shall be supplied to the controller location and the backflow preventer location by a licensed electrician.

3.17 TESTING

A. Upon completion of the irrigation system's mainline, the entire mainline shall be tested with the Owner's Representative present, for a one hour period at 100 psi, unless otherwise noted. Prior to testing, the mainline shall be partially backfilled, leaving all joints and connections exposed for visual inspection. All dirt shall be flushed from the system and the line filled with water to remove air. The mainline shall be brought to static pressure. A pressure gauge and temporary valve shall be installed at the end of the mainline to permit air pressure to be applied to the main. A pressure of 100 psi shall be retained for a one hour period. Any leaks occurring during the one hour pressure test shall be repaired and the system retested until the system passes the test.

B. Upon completion of the lateral piping sections, each lateral system shall be pressure tested, with the Owner's Representative present for one hour at 100 psi. On systems using flex nipples or swing joints, the lateral system shall be tested prior to installation of the flex nipples or swing joints. Prior to testing, the lateral lines shall be partially backfilled leaving all joints and connections exposed for visual inspection. All air and dirt shall be flushed from the system and all open fittings shall be capped. The testing procedure shall be the same as used for the main line. Any leaks occurring during the hydrostatic test shall be repaired and the system retested until the system passes the test. If after one hour 100 psi pressure has been retained, the heads shall be installed, and the backfill operation completed.

C. The Contractor shall be responsible for payment of construction observations for retesting of any lines or system components that fail initial pressure or performance test. Costs shall include the time of the observer at the observer's standard rate, travel time and travel expenses.

3.18 ADJUSTING OF SYSTEM

A. After completion of testing and installation, the Contractor shall adjust all valves for the proper operating pressure and adjust all heads for uniform coverage and even flow. Contractor shall wire the controller to have station numbers correspond with valve numbers indicated on the Drawings or as directed by the Owner's Representative. The valve number shall be indicated on the controller panel for each station. Contractor shall program the controller to provide optimum system performance.

3.20 CLEAN UP

A. The Contractor shall continuously keep a neat and orderly area in which he is installing the

system. Disposal of rubbish and waste material resulting from the installation shall be continual. Upon completion of the system, the Contractor shall remove from the Owner's property at his own expense, all temporary structures, rubbish, waste material, tools and equipment resulting from or used in the installation of the system.

3.21 PROTECTION OF EXISTING UTILITIES

A. The Contractor shall be responsible for locating all existing cables, conduits, piping, and any other utilities or structures that may be encountered either above or below ground. All necessary precautions shall be taken by the Contractor to prevent any damage to the existing utilities and improvements. In the event that such damage should occur from his operations, the Contractor shall repair or replace damaged utilities to their original condition at no expense to the Owner.

3.22 ROCK

A. If the Contractor encounters rock or other unfavorable trenching conditions, no additional compensation will be paid. When material from the excavation or trenching is unsuitable for use as backfill, additional backfill material suitable for this purpose shall be brought in at the expense of the Contractor. It shall be the Contractor's responsibility to remove and dispose of all unsuitable materials removed from the trench that cannot be used in the backfill operation.

3.23 FINAL ACCEPTANCE

A. When the Contractor is satisfied that the system is operating properly, that it is balanced and adjusted and that all work and clean-up is completed, he shall issue a notice of completion to the Owner’s Representative requesting a final observation. The Owner’s Representative will respond to the notice of completion and shall appear with the Owner for an observation of the project. At that time the Contractor shall demonstrate the operation of each system in its entirety. In reviewing the work, no allowance for deviation from the original Drawings and Specifications will be made unless prior approval has been obtained.

B. Any inconsistency to the Specifications or the Drawings will be noted by the Owner’s Representative and a written copy of required corrections shall be given to the Contractor. The Contractor shall complete all corrections in a timely manner and then shall issue a request to the Owner’s Representative for an inspection of corrected work. Final acceptance will not occur until correction of all items work is complete.

3.24 OPERATIONAL INSTRUCTION

A. After the system has been tested and accepted, the Contractor shall instruct the Owner’s Representative on the operation and maintenance of the system.

B. The Contractor shall provide the Owner with two (2) keys for each of the following:

1. manual isolation valves

2. manual drain valves
3. valve boxes
4. controller enclosure
5. backflow preventer enclosure
6. quick couplers
7. any locking assembly in need of key access

C. The Contractor shall provide the Owner with two copies of a Maintenance Manual bound in a three ring binder. The maintenance manual shall include copies of the approved submittals, operation manuals and manufacturer's warranties on all irrigation products.

3.25 SYSTEM MAINTENANCE AND GUARANTEE

A. Maintenance of the irrigation system shall begin immediately following the installation of the system and shall continue until the entire project is accepted. Maintenance shall include repair of defects or damages, adjustments and fine tuning of the system, and repairs of damages resulting from vandalism, erosion, weather, and the like.

B. For a period of one (1) year from final acceptance of the entire project, the Contractor shall promptly furnish and install, without cost to Owner, any and all parts or materials which prove defective in material or workmanship. Damage to the landscape or other property due to irrigation system line breaks shall be repaired and brought to original condition by the Contractor at no expense to the Owner.

C. In the fall, at the Owner's request, the Contractor shall drain the system, and otherwise prepare the system for winter. In the spring, at the Owner's request, the Contractor shall reactivate the system, repair any defects or damage and adjust the system. As these services are performed, the Contractor shall instruct the Owner.

D. For a period of one (1) year from final acceptance of the system, the Contractor shall repair any settlement of trenches by one of the following methods as directed by the Owner's Representative.

1. Turf areas:
   a. Bring to grade by top-dressing (raking topsoil into the grass).
   b. Bring to grade with planting soil mixture and install seed mix to match existing turf.
3. Sod areas or tree/shrub planting areas: Remove existing sod or mulch. Fill depression with planting soil mixture, and replace with new sod or mulch to match existing.

Repair by any of the above methods shall result in a smooth, level area.

3.26 OBSERVATIONS

A. The following observations shall be the minimum required observations during the course of construction. Additional observations shall be made at any time at the discretion of the Owner's Representative. It shall be the responsibility of the Contractor to notify the Owner's Representative, in writing, 48 hours in advance of each required observation.

The sequence of required observations shall not be changed from the sequence listed below. The Contractor shall not proceed with work of the next sequence without written approval of the work of the previous sequence. The Contractor shall attach a copy of the written observation approvals to all applications for payment.

1. Observe staked locations of mainline, valves, laterals and heads.
2. Observe installation and pressure test of mainline.
3. Observe 24 volt control wire installation and ensure that existing controller operates all valve zones properly.
4. Observe installation and pressure test of automatic valves and lateral lines prior to installation of flex nipples, swing joints, and heads.
5. Observe head placement, coverage and operating pressure prior to planting.
6. Observe at final project review.
7. Observe 11 months after final project acceptance.

END OF SECTION

SECTION 329220 – REVEGETATION SEEDING

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. Work under this section consists of preparing all areas indicated on the Drawings for revegetation seeding and furnishing and installing seed as specified herein.

1.2 SUBMITTALS

A. Furnish supplier literature of the following prior to construction:

1. Seed
2. Wood cellulose mulch

B. Furnish the following the same day materials are delivered to the project site:

1. Delivery tickets indicating species and quantity of seed delivered

PART 2 - PRODUCTS

2.1 SEED

A. Seed shall be as specified on the drawings.

B. Each bag of seed shall be sealed and labeled by the seed dealer in accordance with Federal Seed Laws and New Mexico Department of Agriculture Labeling Laws. This includes: species and variety of seed, lot number, purity, germination, percent crop, percent inert, percent weed (including noxious weeds), origin, test date and net weight. Per Federal Seed Laws, analysis shall be no older than 9 months for seed shipped intra-state.

2.2 WOOD CELLULOSE MULCH

A. Wood cellulose mulch shall consist of a specially prepared virgin wood fiber processed to contain no growth-inhibiting or germination-inhibiting factors. Mulch shall be manufactured and processed so that wood cellulose fibers remain in uniform suspension in water under agitation and will blend with grass seed, tackifier, and other additives to form a homogenous slurry.

Provide processed mulch materials with the following characteristics:
1. Can form a blotter-like ground cover on applications
2. Has moisture and percolation properties; and
3. Can cover and hold grass seed in contact with soil

2.3 TACKIFIER

A. Tackifier shall be a safe, nontoxic, plant material or polymer based product that is specifically designed for use in hydroseeding, and with wood cellulose mulch.

PART 3 - SEED BED PREPARATION

3.1 PREPARATION

A. Prior to start of soil preparation finish grade shall be established and approved as meeting the requirements of the Drawings.

B. Rip seed bed in two directions and plow with a 'plow disc' to a minimum of six (6) inches. Remove all stones larger than 2” diameter. Remove all trash, debris, vegetation, dirt clods or other material that would interfere with seeding operations.

C. Tillage shall be performed across the slope when practical. No work shall be done when the moisture content of the soil is unfavorable or the ground is otherwise in non-tillable condition.

D. The extent of seed bed preparation shall not exceed the area on which the entire seeding operation can be applied to such prepared seed bed prior to any surfaces crusting or loss of seed due to erosion. If erosion or crusting occurs, the entire area affected shall be reworked beginning with seed bed preparation.

E. Prior to seeding, the finish grade shall be brought to a firm, even surface, free from stones, lumps, debris, vegetation and dirt clods, and shaped to provide drainage in accordance with the Drawings. The finish grade shall be inspected and approved by the Owner’s Representative prior to seeding.

PART 4 - SEEDING

4.1 The seed mix and rate shall be as specified on the Drawings. The prescribed mix shall be uniformly applied over the area to be seeded at the rate indicated on the Drawings.

4.2 Contractor's vehicles and other equipment shall not travel over the seeded areas. If, as determined by the Owner's Representative, rain or some other factor occurs over prepared surfaces prior to seeding which prevents seeding to the proper depth, the Contractor shall again prepare the seed bed at no additional cost to the Owner.

4.3 TIME OF SEEDING

Native grass revegetation seeding shall be accomplished from April 15 through August 30. If seeding is not accomplished during the "time of seeding" the Contractor shall accomplish the seeding at the "time of seeding" during the next calendar year. Extension of the Contract to meet the "time of seeding" shall be accomplished at no additional expense to the Owner.

4.4 SEEDING OPERATIONS

A. Native seed shall be sown by hydroseeding. Seed shall not be sown during windy weather.

1. Hydraulic mulching equipment shall include a pump capable of being operated at 1000 GPM and 100 PSI pressure. The equipment shall have a pressure gauge and

a nozzle adaptable to hydraulic seeding requirements. Storage tanks shall have a means of estimating the volume used to volume remaining in the tank.

2. Wood cellulose fiber for hydraulic seeding shall not contain any substance or factor which might inhibit germination or growth of seed. It shall be dyed an appropriate color to allow metering of its application. The wood cellulose fiber shall have the property of becoming evenly dispersed and suspended when agitated in water. When sprayed uniformly on the surface of the soil, the fiber shall form a blotter-like ground cover which readily absorbs water, and allows infiltration to the underlying soil. Weight specifications from suppliers, and for all applications shall refer only to air dry weight of the fiber, a standard equivalent to 10% moisture. The mulch material shall be supplied in packages having a gross weight not in excess of 100 pounds, and shall be marked by the manufacturer to show the air dry weight content. Suppliers shall certify that laboratory and field testing of their product has been accomplished and that it meets all of the foregoing requirements pertaining to wood cellulose fiber mulch.

3. Wood cellulose fiber mulch shall be added with the proportionate quantities of water and other approved materials in the slurry tank. All ingredients shall be mixed to form a homogeneous slurry. Using the color of the mulch as a metering agent, the operator shall spray-apply the slurry mixture uniformly over the designated seeded area. Unless otherwise ordered for specific areas, wood cellulose fiber mulch shall be applied at the rate of 1,400 pounds per acre.

4. Hydraulic seeding shall not be done in the presence of free surface water resulting from rains, melting snow or other causes or during windy weather.

4.5 OBSERVATION

A. The following observations shall be the minimum required observations of revegetation seeding during the course of construction. Additional observations shall be made at any time at the discretion of the Owner's Representative. It shall be the responsibility of the Contractor to notify the Owner's Representative, in writing, 48 hours in advance of each required observation. The sequence of required observations shall not be changed from the sequence listed below. The Contractor shall not proceed with work of the next sequence without written approval of the work of the previous sequence.

1. Finish grade shall be observed.
2. Seeding operations shall be observed.
3. Seeded area shall be observed after completion.
4. Seeded area shall be observed at the final walk-through.

END OF SECTION

SECTION 329223 - SODDING

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. Work under this section consists of preparing all areas indicated on the Drawings for grass sodding according to the specifications and furnishing and installing all sod, fertilizer and soil amendments as specified herein.

1.2 REFERENCE STANDARDS

A. ASPA (American Sod Producers Association) - Guideline Specifications to Sodding.

1.3 SUBMITTALS

A. Furnish soil test results for any fill that has been imported into landscape areas prior to start of landscape construction.

B. Furnish supplier literature and chemical analysis (or botanical analysis for sod) of the following prior to construction:

1. Organic amendments
2. Chemical fertilizer
3. Soil conditioner
4. Sod

C. Furnish the following the same day materials are delivered to the project site:

1. Delivery tickets indicating quantity of material delivered for:
   a. Organic amendments
   b. Chemical fertilizer
   c. Soil conditioner

PART 2 - PRODUCTS

2.1 SOD

A. Sod shall be as specified on the Drawings. A sample of sod and a written submittal of the seed mix shall be submitted a minimum of fifteen (15) days prior to laying of sod. Sod shall be vigorous, well rooted healthy turf free from disease, insect pests, weeds, other grasses, stones and other harmful or deleterious matter.

B. Sod shall be cut by an approved mechanical sod cutter to a thickness of not less than 1" or more than 2". Sod pieces shall be cut a maximum of 18" wide. Handling of sod shall be done in a manner that will prevent tearing, breaking, drying or any other damage. Sod shall be installed in place on the site not more than 24 hours after cutting.

C. Sod shall have no more than 2" of loose thatch. The sod shall be dense enough so that an

entire strip can be lifted by the top 10% without breaking.

2.2 FERTILIZER

A. Fertilizer shall be a granular form fertilizer with a guaranteed analysis of 18-24-12 or as specified in the recommendations of the soil test results.

2.3 ORGANIC AMENDMENTS

Organic amendment shall consist of:

A. Aged screen bark amendment. Amendment shall consist of 3-5 year old bark fines from coniferous trees with a pH of 6.0 or less. Material shall be minimum 90% organic, free of rocks, weeds, weed seed or any other material deleterious to plant growth. Product shall be heat treated by the composting process and screened to ½" minus. ~~70% by volume, organic compost. Compost shall be a well decomposed, stable, weed free organic matter source. It shall be derived from agricultural, food, or industrial residuals, biosolids, yard trimmings, source separated or mixed solid waste. The product shall contain no substances toxic to plants and shall be reasonably free (<1% by dry weight) of man-made foreign matter. The compost will possess no objectionable odors and shall not resemble the raw material from which it was derived. The product shall meet the standards established through the US Composting Council's Seal of Testing Assurance Program." Compost to be screened to 1/2" minus, pH within a range of 6.0-8.5. Electrical conductivity (EC) of compost not to exceed 10 mmhos/cm. Percentage of organic matter shall be in the range of 30-65%, tested by simple combustion~~. Compost provider shall be permitted through the NMED.

~~B. 30% by volume, clean, screened, white vitric tuff, screened to pass #40 mesh.~~

~~D. Components to be homogeneously mixed, in ten cubic yard batches to provide a uniform product, free from weed seeds, sticks, rocks, or other deleterious material.~~

F. Each Delivery shall have a load ticket. The load ticket shall list:
Type of Mixture
Source of Mixture.
Approximate volume of load.
Date of delivery of loading.
Name of individual representing the source.

Ticket shall be collected and provided to the Owner's Representative.

2.4 SOIL CONDITIONER

A. Granulated 90% sulfur
~~A.~~B. 70% HA Screened Humate – 7x18 Mesh

2.5 ADDITIONAL AMENDMENTS

A. Gypsum

PART 3 - EXECUTION

3.1 SOD BED PREPARATION

A. Prior to start of soil preparation soil shall be cleared of rocks and lumps of 1" diameter and greater, vegetation and debris to a minimum depth of 12". Finish grade shall be established and approved as meeting the requirements of the grading plan.

B. Rip all areas to be sodded to a depth of 12". Apply 4 cubic yards of amendment per 1000 square feet, ~~a uniform 2" layer of organic amendment,~~ 4 lbs. of fertilizer per each 1000 square feet, 10 pounds granulated sulfur soil conditioner per each 1000 square feet, 1 ton of humate soil conditioner per acre, and 1 lb gypsum per each 10000 square feet to the entire area to be sodded. After application of organic amendment, fertilizer, soil conditioner, and gypsum all areas to be sodded shall be thoroughly rototilled at cross directions to a minimum depth of 6 inches. After rototilling is complete at cross directions, drag to an even grade, then roll for firmness.

C. If the Contractor has imported fill into a landscape area, the Contractor shall coordinate with the Owner's Representative to have samples of the fill submitted to an independent soil testing laboratory for nutritional analysis. The cost of the soil testing shall be paid by the Contractor. If recommended by the soil test laboratory, the Contractor shall revise the specified fertilizer, organic amendments and soil conditioner to be in accordance with the recommendations specified on the soil test report. If recommended by the soil test laboratory, the Contractor shall provide and incorporate additional fertilizers and soil amendments into the fill in the landscape area in accordance with the recommendations specified on the soil test report.

3.2 SOD INSTALLATION

A. Before laying sod, the finish grade shall be brought to a firm, even surface, free from stones and lumps 1" diameter and greater, and shaped to provide drainage in accordance with the Drawings. The finish grade shall be inspected and approved by the Owner's Representative prior to laying any sod.

B. Lay sod over moistened soil lightly raking the soil ahead of each sod strip. Sod shall be laid perpendicular to the direction of slope and shall have staggered joints. Pieces shall be fitted together tightly so that no joint is visible, and sod tamped firmly and evenly by hand. Stake as required on slopes.

C. After sodding is completed, all sod areas shall be rolled. Rolling shall be done in two directions perpendicular to each other. After rolling, repair and reroll any areas where depressions or other irregularities occur.

D. Water all sodded areas immediately after final rolling with fine spray to a depth of 4". Irrigate by means of the automatic underground irrigation system all sodded areas as often as necessary to promote healthy grass growth. Mowing during the maintenance period shall be scheduled so that the grass is maintained at a height no shorter than two (2) inches and no greater than three (3) inches.

E. Contractor shall not lay sod during freezing temperatures or over frozen soil. If sod cannot be installed due to freezing temperatures and/or frozen soil, Contractor shall postpone installation of sod until the temperature and soil conditions meet the requirements of these specifications.

3.3 MAINTENANCE AND PROTECTION

A. Maintenance and protection shall continue until the entire project is accepted. Acceptance shall occur after all sod is well rooted.

B. Maintenance shall include watering, weeding, cultivating, fertilizing, removal of dead material and debris, and such other operations as may be necessary for the health of the sod and the general appearance of the landscaped areas. Protection shall include care or replacement of the sod from damages resulting from trespass, erosion (including watering), weather, vandalism, disease and the like.

3.4 WARRANTY

A. Sod shall be guaranteed to be in a live, healthy, and normal growing condition through twelve months from the date of final acceptance by the Owner's Representative. The Contractor shall not be held responsible for replacement of sod lost through vandalism and/or other destruction after contract final acceptance.

B. The Contractor shall monitor the condition of the sod at regular intervals during the warranty period to verify that the sod is receiving proper maintenance. Frequency of monitoring visits shall be as required to ensure proper maintenance. If at any time during the warranty period the Contractor should encounter at the site conditions unfavorable to the health of the sod, he shall notify the Owner and Owner's Representative of such in writing. Inadequate or improper maintenance by the Owner during the warranty period will not relieve the Contractor of his warranty obligation, unless such improper maintenance continues beyond the date the Contractor has notified the Owner and Owner's Representative.

C. Sod that is dead or in an unhealthy, impaired growth condition during the warranty period shall be removed and replaced by the Contractor. Replacement material shall match quality and species of the sod originally specified and shall be approved by the Owner's Representative prior to installation. Sod replaced during the first six months of the warranty period shall be under warranty until the end of the warranty period. Sod replaced after the first six months of the warranty period shall-be under warranty for six months after the replanting date.

3.5 OBSERVATIONS

A. The following observations shall be the minimum required inspections during the course of construction. Additional observations shall be made at any time at the discretion of the Owner's Representative.

B. It shall be the responsibility of the Contractor to notify the Owner's Representative, in

writing, 48 hours in advance of each required observation.

C. The sequence of required observations shall not be changed from the sequence listed below. The Contractor shall not proceed with work of the next sequence without written approval of the work of the previous sequence.

1. Automatic irrigation system shall be installed, tested, and approved.
2. Each phase of soil preparation shall be observed in process.
3. Finish grade shall be observed.
4. Sod shall be observed prior to laying.
5. Sod shall be observed after installation.
6. Sod shall be observed at final project review.
7. Sod shall be observed 11 months after final project acceptance.

END OF SECTION

SECTION 329300 - PLANTS

PART 1 - GENERAL

1.1 SUMMARY

A. Work under this section consists of the planting of trees, shrubs, and ground covers, including the furnishing of all labor, equipment, and materials and performing all work in connection therewith in accordance with the Drawings and Specifications.

1.2 PLANT NAMES

A. The botanic and common names used for the plants called for on the Drawings are generally in conformity with the approved names given in Standardized Plant Names, 1980 Edition, published by The American Joint Committee on Horticultural Nomenclature. The names of varieties not included therein are generally in conformity with the names accepted in the nursery trade.

1.3 PLANT MATERIAL SUBSTITUTIONS

A. Plant material substitutions shall not be made without the written permission of the Owner's Representative. The use of materials differing in kind, quality or size from that specified shall be allowed only after the Owner's Representative is convinced that all means of obtaining the specified materials have been exhausted. At the time bids are submitted, the Contractor is assumed to have located the materials necessary to complete the job as specified. All requests for substitutions shall be submitted no later than five (5) working days prior to the opening of bids.

1.4 SUBMITTALS

A. Furnish samples of the following prior to construction:

1. Mulch

B. Furnish supplier literature and chemical analysis of the following prior to construction:

1. Backfill amendment
2. Soil conditioner
3. Filter fabric

C. Furnish delivery tickets the same day materials are delivered to the project site for the following:

1. Backfill amendment
2. Soil conditioner

PART 2 - MATERIALS

2.1 PLANT MATERIALS

A. A complete plant list, including quantities, sizes and other requirements is shown on the Drawings. In the event that a discrepancy occurs between quantities of plants indicated in the plant schedule and on the planting plan, the plant quantities indicated on the planting plan shall govern.

2.2 PLANT MATERIAL QUALITY

A. Plant material quality, size and condition shall be in accordance with American Standard for Nursery Stock, 1986, as published by the Committee on Horticultural Standards of the American Association of Nurserymen, Inc., the Drawings, and the following requirements:

1. All plants shall be typical of their species or variety. All plants shall have normal, well developed branches and vigorous root systems. They shall be sound, healthy, vigorous, and free from defects, disfiguring knots, abrasions of the bark, sunscale injuries, plant diseases, insect eggs, borers, and all other forms of infections.

2. Unless otherwise stated on the Drawings or approved by the Owner's Representative, all plants shall be nursery grown and shall be tagged with nursery labels indicating species and variety.

3. Container grown plant material shall have been grown in its delivery container for not less than six (6) months, but for not more than two (2) years. Any rootbound material will not be accepted.

4. Multi-stem: All countable stems, in aggregate, shall average the size specified. To be considered a stem, the division of the trunk shall be no more than six inches from ground level.

5. Balled and burlapped plant material shall have a solid ball of earth of minimum specified size held in place securely by burlap and stout twine or rope. Light poultry binding is acceptable. Stout wire or wire baskets are acceptable only as a temporary means for securing burlap until tree is in place. Broken or loose balls will be rejected.

6. Unless specifically noted on the Drawings, all trees shall have a single trunk that is straight and free of "dog legs", "crooks", "Y-crotches", or other disfiguring shapes. The central leader of all trees shall not have been pruned. Trees with double leaders are not acceptable.

7. All plant material shall have a uniform shape around its complete circumference. Plant material with irregular branching patterns or with branching patterns more highly developed on one side than on other sides will not be accepted.

8. All plant material shall be reviewed by the Owner's Representative at the Contractor's yard or at a wholesale nursery of the Contractor's choice prior to

delivery to the job site. All material shall then be reviewed after planting.

10. The Contractor shall mark each plant intended for use on the project with an identifying tag prior to the Owner's Representative's review of the plants.

11. The Owner's Representative shall be the judge of the quality and acceptability of all plant material. All rejected material shall be immediately removed from the site and replaced with acceptable material at no additional cost to the Owner.

2.3 PLANTING SOIL MIXTURE

A. Planting Soil Mixture shall be a mixture of one part backfill amendment to two parts existing soil.

The backfill amendment shall consist of:

1. 70% by volume, organic compost. Compost shall be a well decomposed, stable, weed free organic matter source. It shall be derived from agricultural, food, or industrial residuals, biosolids, yard trimmings, source separated or mixed solid waste. The product shall contain no substances toxic to plants and shall be reasonably free (<1% by dry weight) of man-made foreign matter. The compost will possess no objectionable odors and shall not resemble the raw material from which it was derived. The product shall meet the standards established through the US Composting Council's Seal of Testing Assurance Program." Compost to be screened to 1/2" minus, pH within a range of 6.0-8.5. Electrical conductivity (EC) of compost not to exceed 10 mmhos/cm. Percentage of organic matter shall be in the range of 30-65%, tested by simple combustion. Compost provider shall be permitted with the NMED.

2. 30% by volume clean, screened, white vitric tuff, graded to 3/16" x 5/16".

2. Components to be homogeneously mixed, in ten cubic yard batches to provide a uniform product, free from weed seeds, sticks, rocks, or other deleterious material.

3. Each delivery shall have a load ticket. The load ticket shall list:
Type of Mixture
Source of Mixture.
Approximate volume of load.
Date of delivery or loading.
Name of individual representing the source.
Ticket shall be collected and provided to the Owner's Representative.

2.4 SOIL CONDITIONER

A. Shall be granulated 90% sulfur.

2.5 MULCH

A. Mulch shall be as specified on the Drawings.

PART 3 - EXECUTION

3.1 PLANTING OPERATIONS

A. Prior to planting operations, landscape areas shall be cleared of rocks and lumps greater than 1" diameter, vegetation, and debris to a minimum depth of 12" and finish grading shall be complete and accepted by the Owner's Representative. Planting operations shall be performed only during favorable weather conditions in accordance with accepted practice.

B. In any one day, only those plant materials intended to be planted that day shall be delivered to the project site. Unless otherwise approved by Owner's Representative, all plant materials shall be located where shown on the Drawings except when adjustments due to field conditions are required. The location of all trees and shrubs shall be staked by the Contractor and reviewed by the Owner's Representative prior to installation. Tree locations shall be represented by using 1" x 2" x 12" wood stakes or colored flags. The name of the tree shall be indicated on the stake or flag so it is readily identified. Shrub locations shall be determined by colored flags or by placement of containerized plant material.

3.2 PLANTING

A. Planting and backfilling shall be performed in accordance with accepted nursery practice, the Drawings, and the following requirements:

1. The Contractor shall take care when backfilling planters to provide adequate compaction of the fill material in order to prevent settling.

2. Prepare all planting pits and install plants as shown on Drawings. Plants shall be set plumb and straight.

3. Remove wire basket, wood box, plastic, twine, and/or rope prior to backfill. Remove burlap except from bottom of root ball prior to backfill.

4. Backfill for planting pits shall consist of the specified planting soil mixture and .10 pounds soil conditioner per cubic foot of backfill. The plant shall be positioned in the hole, and backfilled. The backfilling shall be completed, and material tamped. When pit is nearly filled, water thoroughly and allow water to soak away. If settling of backfill occurs after watering, add more backfill to bring to finish grade.

5. After completion of planting, trees shall be pruned at the direction of the Owner's Representative.

3.3 MULCH

A. Mulch shall be completed as indicated on the Drawings.

B. Avoid placing mulch against the trunk or stem of any plant material.

3.4 MAINTENANCE AND PROTECTION

A. Maintenance and protection of trees, shrubs, and ground covers shall begin immediately following the installation of each plant and shall continue until the entire project is accepted. Maintenance shall include watering, weeding, cultivating, removal and replacement of dead plant material, removal of debris, resetting of trees to upright positions, restoration of earth basins, and such other operations as may be necessary for the health of the planted stock and the general appearance of the landscaped areas. Maintenance and protection shall include repair of damage to plants and replacement of severely damaged plants resulting from trespass, erosion (including erosion from application of irrigation water), weather, vandalism, disease or other condition or action.

3.5 WARRANTY

A. All plant materials shall be guaranteed to be in a live, healthy, and normal growing condition from the date of final project acceptance through one twelve month period. The Contractor shall not be held responsible for replacement of plants and materials lost through vandalism and/or other destruction after final project acceptance.

B. The Contractor shall monitor the condition of the landscape at regular intervals during the warranty period to verify that the landscape is receiving proper maintenance. Frequency of monitoring visits shall be as required to ensure proper maintenance. If at any time during the warranty period the Contractor should encounter at the site conditions unfavorable to the health of the planted stock, he shall notify the Owner and Owner's Representative of such in writing. Inadequate or improper maintenance by the Owner during the warranty period will not relieve the Contractor of his warranty obligation, unless such improper maintenance continues beyond the date the Contractor has notified the Owner and Owner's Representative.

C. Plant materials that are dead or in an unhealthy, impaired growth condition during the warranty period shall be removed and replaced by the Contractor as directed by the Owner's Representative at no additional cost to the Owner. Replacement material shall be of equal quality, size, and species as that which is being replaced and shall be approved by the Owner's Representative prior to planting. Plants replaced during the first six months of the warranty period shall be under warranty until the end of the warranty period. Plants replaced after the first six months of the warranty period shall-be under warranty for six months after the replanting date.

3.6 REVIEWS

A. The following observations shall be the minimum required observations during the course of construction. Additional observations shall be made at any time at the discretion of the Owner's Representative. It shall be the responsibility of the Contractor to notify the Owner's Representative, in writing, 48 hours in advance of each required observation. The sequence of required observations shall not be changed from the sequence listed

below. The Contractor shall not proceed with work of the next sequence without written approval of the work of the previous sequence.

1. Review plant material at Contractor's yard or wholesale nursery prior to delivery to job site.
2. Review staked locations of plant material prior to planting.
3. Review of planting operations.
4. Review at final project completion.
5. Review 11 months after final project acceptance.

END OF SECTION

SECTION 33 1000

WATER UTILITIES

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. Pipes, materials and appurtenances for potable water systems.

B. Installation.

1.02 REFERENCES

A. NMAPWA Construction Standards and Specifications.

B. AWWA:

1. C110: Gray iron and ductile iron fittings 3" through 48" for water and other liquids.
2. C600: Installation of Ductile-Iron Water Mains and Their Appurtenances.
3. C605: Underground Installation of Polyvinyl Chloride (PVC) Pressure Pipe and Fittings for Water.
4. C700: Cold water meters - displacement type.
5. C900: Polyvinyl chloride (PVC) pressure pipe 4" through 12" for water.
6. C905: Polyvinyl chloride (PVC) pressure pipe 14" through 36" for water.

C. ASTM:

1. A370: Mechanical Testing of steel products.
2. A536: Ductile iron castings.
3. D1330: Rubber sheet gaskets.
4. D1598: Test for time-of-failure of plastic pipe under long-term hydrostatic pressure.
5. D1599: Test for short-term rupture strength of plastic pipe, tubing and fittings.
6. D1784: Polyvinyl chloride (PVC) compound and chlorinated polyvinyl chloride (PVC) compounds, rigid.
7. D1785: Polyvinyl chloride (PVC) plastic pipe, Schedules 40, 80 and 120.
8. D1869: Rubber rings for asbestos cement pipe.
9. D2239: Polyethylene plastic pipe.
10. D2241: Polyvinyl chloride (PVC) plastic pipe (SDR-DO).
11. D3139: Joints for plastic pressure pipes using flexible elastomeric seals.
12. E8: Tension testing for metallic materials.

1.03 SUBMITTALS

A. Submittals per Section 01 33 00.

B. Product Requirement: Section 01 60 00.

C. Manufacturer's installation recommendations.

1.04 GENERAL REQUIREMENTS

A. Pipes, fittings and materials to be new, of highest quality and shall be in first class condition when installed.

B. Pipe, fittings and appurtenances of the same type and made by the same manufacturer.

C. Provide labor, equipment and materials for pipe field testing.

D. Contact and coordination with utility's owner is the full responsibility of the Contractor.

1.05 HANDLING AND STORAGE OF PIPE AND APPURTENANCES

A. Pipe, valves, hydrants, and other appurtenances shall, unless otherwise directed, be unloaded, hauled and laid as follows:

1. Pipe and appurtenances shall be lifted by hoists with broad well-padded contact surfaces, or rolled on skidways in such a manner to avoid shock.
2. Under no circumstances shall pipe or appurtenances be dropped.
3. Pipe must not be rolled or skidded against pipe already on the ground.

B. The Contractor shall be responsible for the safe storage of material furnished by or to him and accepted by him, and intended for the work, until it has been incorporated in the completed project.

C. Installation:

1. In distributing material at the site of the work, each piece shall be unloaded opposite or near the place where it is to be laid in the trench.
2. Pipe shall be handled in a manner that only a minimum amount of damage to the pipe exterior will result. Damaged piping shall be repaired in a manner satisfactory to the Engineer or replaced.
3. The interior of all pipe, fittings, and other appurtenances shall be kept free from dirt and foreign matter at all times.

1.06 QUALITY ASSURANCE

A. Ductile Iron:

1. Tests:
   - **a ASTM E8: Tension Testing of Metallic Materials.**
   - **b ASTM E23: Impact Test.**
2. Marking: cast on each pipe length:
   - **a Weight, class, nominal thickness and casting period.**
   - **b Manufacturer's name, year of production and the letters "DI" or the words "Ductile Iron."**

B. PVC Pipe and Fittings:

1. Tests: ASTM D3034
2. Marking: indelible, in each pipe:
   - **a. Diameter and cell classification.**
   - **b. Manufacturer's name, ASTM, SDR or Schedule and date of production.**
   - **c. Service designation.**
   - **d. NSF approved.**
3. Rubber rings: marked with the manufacturer's identification, size, year of production and classes of pipe in which they are to be used.

C. Valves:

1. Valves shall be built and equipped for the type of operation shown on the Plans or as directed by the Engineer.
2. All valves shall be of standard makes approved by the Engineer and shall have the name, monogram, or initials of the manufacturer cast thereon.

3. Dielectric gaskets or unions will be used when dissimilar metals are connected to each other

PART 2 PRODUCTS

2.01 MATERIALS AND FABRICATION

A. Ductile Iron:

1. Pipe:

a. ANSI A21.51 (AWWA C151).

b. ASTM A536, Grade 60-42-10.

c. Ductile iron pipe shall meet ANSI/AWWA A21.51/C151 specifications:

2. Fittings:

a. Ductile iron, ANSI A21.10 (AWWA C111).

b. ASTM A536, Grade 80-60-03 or 70-50-05.

c. Hydrostatic test: Rated at minimum 150psi.

3. Threaded connections: ANSI B2.1 NPT.

4. Joints:

a. Mechanical: 350 psi working pressure.

b. Flange: DI; ANSI A21.14 or B16.1, 125 lb.

c. Gaskets: ASTM D1330, Grade I.

d. Push-on gaskets: neoprene or other synthetic rubber, D412 and D395. Natural rubber not acceptable.

e. Lubricant: Heavy vegetable soap solution suitable for potable water use.

5. Flanged adapters:

a. Body: ASTM Class 30 cast iron.

b. Flanges: DI ANSI A21.15.

c. Bolts: Steel with heavy hex nuts, ASTM A576.

d. Gaskets: Fastite neoprene.

B. Polyvinyl Chloride (PVC):

1. Pipe and fittings:

a. AWWA C900:

(1) All Sizes: SDR14 or as scheduled.

(2) Pressure Class: 200 psi or as scheduled.

2. Joints:

a. Gasket bell end: ASTM D3139 for plastic pressure pipes using elastomeric seals.

b. Gaskets: ASTM F477, elastomeric.

c. Solvent-Cement: Manufacturer's standard; use only where specifically scheduled, shown on Drawings or approved by Engineer.

C. Service Lines:

1. High Density Polyethylene up to 2": ASTM D2737, SDR-9, copper pipe size

a. ASTM D2239, SDR-9, iron pipe size; or:

b. ASTM D2737, SDR-7, copper pipe size.

2. Coper, Type K: ASTM B8
3. Minimum pressure rating: 150 psi.
4. Joints:

a. Compression fittings.

b. Compatible with heavy duty copper service fittings.

2.02 APPURTENANCES

A. Fire Hydrants:

1. Latest revision of AWWA C-502.
2. Mueller A423 Super Centurion 250 or Engineer-approved equivalent.
3. 1-1/2" Pentagon bronze operating nut equipped with elastomer weather seal between the top casting and the operating nut.
4. Sealed oil reservoir will inmate a system of ford lubrication of the thrust collar area each time the hydrant is operated.
5. Two 2.5" and one 4.5" nozzles with National Standard fire hose threads mechanically connected into the barrel, O-ring sealed with National Standard nozzle caps.
6. Steel safety stem coupling with stainless steel fasteners and two-piece breakaway safety flange.
7. Centerline of hose nozzle will be a minimum of 18" above ground line.
8. 5-1/4" diameter main valve opening.
9. Upper valve plate shall be all bronze.
10. All internal surfaces of the shoe, the lower valve plate and cap nut shall be coated with a factory-applied, two-part, thermosetting epoxy coating with a minimum thickness of 4 mils.
11. The bronze valve seat shall be threaded into a bronze drain ring or shoe bushing; the drain channel shall be all bronze.
12. The hydrant shall have two drain outlets above the lower flange of the hydrant shoe assembly.
13. Minimum 200 psi working pressure, and be certified as such by the manufacturer.
14. Lower barrel to shoe connection will have a minimum of six bolts made of stainless steel.
15. All hydrants furnished will have a standard 10-year warranty certified by the manufacturer.
16. Painted chrome yellow.
17. One Manufacturer’s hydrant wrench supplied with each hydrant installed.

B. Resilient Wedge Gate Valves:

1. Size as shown on Drawings.
2. Mueller, Clow, Waterous, American Darling, Resilient Wedge Gate Valves or Engineer approved equivalent.
3. Valves shall conform to AWWA C-509 and comply with its latest revisions.
4. The wedge shall be cast iron, fully encapsulated in molded rubber including the guides. The bronze stem nut must be rigidly enclosed in the wedge to maintain alignment.

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5. The stem shall have two O-rings above and one O-ring below the collar. Stem seats must be replaceable with the valve under pressure.
6. The stem material shall be stainless steel (AISI420) or Engineer-approved equivalent.
7. The waterway shall be full size to allow for tapping use; no cavities or depressions are permitted in the seat area.
8. Valve body and bonnet shall be electrostatically applied, fusion bonded and epoxy coated, both inside and out, by the valve manufacturer. The coating shall meet the requirements of AWWA C-550. Coating to be applied only at the valve manufacturer's facilities.
9. The bonnet bolts shall not be exposed to the environment or, alternatively, be in 316 stainless steel.
10. O-ring style seals shall be used as gaskets on the bonnet and on the stuffing box.
11. All valves must be tested by hydrostatic pressure equal to the requirements in the AWWA C-509 specifications prior to shipment from the manufacturer.
12. 2-inch AWWA operating nut for valves in below-ground service; handwheel for above-ground service.
13. Mechanical joint ends for pipe or as shown on drawings.

C. Swing Check Valves:
1. 3" and smaller: bronze, swing disc, screwed ends.
2. 4" and larger: iron body, bronze trim, swing disc, renewable disc and seat, outside weight and lever for exposed service, flanged ends.

D. Air Pressure and Vacuum Relief Valves:
1. Cast iron body, cover and baffle; stainless steel trim and float.
2. Sized for up to 800 gpm; 0 - 250 psi.
3. Seat: Buna-N.
4. 3" and smaller: NPT threaded outlet.
5. 4" and larger: Plain outlet with steel protector hood.
6. Val-Matic, Crispin or Engineer-approved equivalent.

E. Backflow Preventer:
1. Zurn 375DA or approved equivalent

F. Valve Boxes:
1. Cast iron, adjustable extension, traffic type.
2. Minimum thickness of metal at any point: 3/16".
3. Removable cast iron cover.
4. For valves on washwater and irrigation system only: Class 200 PVC pipe.
5. All valve boxes for plug valves shall be designed for integral installation of the required valve position indicator.
6. Cast iron boxes: Factory painted inside and out with manufacturer's recommended asphalt paint.
7. Cover marked "Water".

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G. Tapping Sleeves:

1. Minimum working pressure 250 psi.
2. Mechanical joint type.
3. Sizes as shown on Drawings.
4. Mueller Type H-615 with two end gasket sets that allow to fit all classes of cast iron pipe or Engineer-approved equivalent.

H. Tapping Crosses:

1. Minimum working pressure 250 psi.
2. Mechanical joint type.
3. Sizes as shown on Drawings.
4. Mueller Type H-715 with two end gaskets sets that allow to fit all classes of cast-in pipe or Engineer-approved equivalent.

I. Tapping Valves:

1. Minimum working pressure 250 psi.
2. Size as shown on the Drawings.
3. Mueller Type H-667 mechanical joint on outlet side and flange end on opposite side; attach to tapping drilling machine, or Engineer-approved equivalent.
4. AWWA C500.

J. Inserting Valves:

1. Sizes as shown on Drawings.
2. Minimum working pressure 250 psi.
3. Comply with Part 2.02C.
4. Mueller Type H-800 for cast iron pipe or Engineer-approved equivalent.
5. Gauges:
6. All gauges shall be 3" in diameter.
7. Each gauge shall be installed with block and bleed valves, and with a snubber and dielectric coupling.

K. Tracer Wire:

1. Conductor shall be solid or stranded copper per ASTM B-1, B-3, or B-8.
2. Insulation of conductor shall be yellow, high molecular weight polyethylene (HMWPE).
3. The temperature rating of the tracer wire shall be 75 degrees Celsius, dry and wet. The voltage rating shall be 600 Volts.
4. Tracer wire shall be installed on all gas/propane and water lines.

L. Sentry Posts:

1. Metal posts.
2. Water pipeline warning sign.
3. Color: blue.

PART 3 - EXECUTION

3.01 INSTALLATION

A. General:

1. Trenching, Backfilling and Compacting: Section 31.00.00
2. Pipe Cutting:
    a. Pipe cutting measurement taken at site.
    b. Cutting of pipe or inserting valves, fittings, or closure pieces shall be done in a neat and workman like manner without damage to the pipe.
3. Direction of Bells:
    a. Unless otherwise directed, pipe shall be laid with bell ends facing the direction in which work is progressing.
    b. Pipe laid on an appreciable slope shall be laid with bell ends facing uphill.
4. Pipe Plugs: At times when pipe laying is not in progress, the open ends of pipe shall be closed by a watertight plug or other means approved by the Engineer.
5. Pipe Cleanliness:
    a. Clean all pipe, fittings and appurtenances before use.
    b. Foreign materials or objects shall be prevented from entering the pipe while it is placed in the trench.
6. Temporarily support, adequately protect and maintain all underground and surface utility structures, drains, sewers, and other obstructions encountered in the progress of work.

B. Pipe Alignment and Grade
1. All pipe shall be laid and maintained to the required lines and grades; with fittings, valves, and hydrants at the required locations, with joints centered and spigots home; and with all valve and hydrant stems plumb.
2. Deviations:
    a. Wherever existing utility structures or branch connections leading to main sewers or to main drains, or other conduits, ducts, pipes or structures present obstructions to the grade and alignment of the pipe, they shall be permanently supported, removed, relocated, or reconstructed by the Contractor through cooperation with the owner of the utility, structure or obstruction involved.
    b. No deviation shall be made from the required line or grade except with the written consent of the Engineer.
    c. The Contractor shall make all necessary explorations to determine the location of existing pipes, valves, or other underground structures. The Owner and Engineer shall furnish all available information; however, such information cannot be guaranteed as accurate.
3. Depth of Bury:
    a. Depth of bury shall be as shown in the Plans.
    b. Minimum depth of bury of 3'-6" as measured from the established road grade or the surface of the permanent improvement to the top of the barrels of the pipe. When crossing the arroyo and/or drainage swales, depth of bury shall be 4’-0”.

C. Pipe Laying:
1. Proper implements, tools, and facilities shall be provided and used for the safe and convenient performance of the work.

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2. All pipe fittings, valves and hydrants shall be lowered carefully into the trench by means of a derrick, ropes, or other suitable tools or equipment, in such a manner as to prevent damage to water main materials and protective coatings and linings.
3. Under no circumstances shall water main materials be dropped into trench.
4. Trench shall be dewatered prior to installation of pipe.

D. Jointing and Assembling:
1. Joints shall be installed in accordance with manufacturer's written Installation and Operation Manual and approved submittals.
2. Lubricants: Vegetable soap solution suitable for use on potable water systems.
3. precaution must be taken to prevent entrance of soil and other contaminants.
4. Use mechanical or push-on for exterior locations.
5. All lumps, blisters, burrs or excess coating shall be removed from the socket and plain ends of each pipe, and the outside of the plain end and the inside of the bell shall be wiped leaned and dry and be free from dirt, sand, grit, or any other foreign materials.

E. Clean all lines by repeated flushings after installation.

F. Disinfection: Refer to NMAPWA Construction Standards and Specifications.

G. Pipe Sleeves:
1. For all pipes passing through concrete or masonry.
2. Install where practical before concrete is placed.
3. Sleeve seal: watertight, modular sealing element when sleeve is placed in slabs with one side against soil.

H. Buried pipe anchorage:
1. Anchors, joint harness or other acceptable means of preventing pipe movement whether indicated or not required for:
   a. Unlugged bell and spigot or all unflanged tees.
   b. Y branches.
   c. Bends deflecting 22 ½ degrees or more.
   d. Plugs and caps.
   e. Fittings in fills or unstable ground.
   f. Above grade or exposed structure.
2. Restrained joints shall be installed within the vicinity of the arroyo and/or drainage swales.

I. Valves: Installed as shown on Drawings with valve boxes and joint restraint.

J. Fire hydrants: As indicated on Drawings with concrete blocking.

3.02 FIELD QUALITY CONTROL

A. All pipes and fittings tested in the presence of and to the satisfaction of the Engineer. AWWA C600 and C605 should be followed for proper pipe installation procedures and hydrostatic testing methods.

B. Test Conditions (PVC):

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1. Medium: Water.
2. Perform test at 150 psi for one hour per 1,000 linear foot of pipe or 2 hours minimum

C. Testing Equipment:

1. Pressure gauge used to perform pressure test shall be a digital type gauge with the ability to display testing pressure to one hundredth (1/100) of a psi. The pressure gauge shall be rated for at least the required testing pressure.
2. All equipment for use in supplying water for the testing procedure shall be for potable water use only. A suitable amount of chlorine should be added to the storage device in order to disinfect such device. Prior notice will be given to engineer of method used for supplying water for testing.
3. When existing water mains are used to supply test water, they should be protected from backflow contamination by temporarily installing a double check-valve assembly between the test and supply main, or by other means approved by the Engineer.
4. All testing equipment are subject to and shall be disinfected per NMAPWA Construction Standards and Specifications, prior to any test. All equipment must pass a bacteriological test prior to being placed in service.

D. Procedure (PVC):

1. Disconnect fixtures, equipment and accessories that may be damaged by test pressure.
2. Plug ends as required.
3. Water shall be applied by means of a pump connected to the pipe in a satisfactory manner.
4. All air shall be expelled from the pipe prior to pressure testing.
5. No installation will be accepted unless the leakage is less than the number of gallons per hour as determined by the formula in New Mexico Standard specifications for Public Works Construction Section 801:
6. Leakage shall be defined as the quantity of water that must be supplied into the pipe section being tested to maintain a pressure within 5 psi of the specified leakage-test pressure after the pipe has been filled with water and the air in the pipeline has been expelled.
7. All joints showing visible leaks shall be properly repaired. Any cracked or defective pipes, fittings, valves, or hydrants discovered in consequence of this pressure test shall be removed and replaced by the Contractor with sound material, and the test repeated.
8. Retest repaired joints, pipes and fittings until system is tight and test results are satisfactory to the Engineer.
9. Pipe testing and preparation for use should strictly follow AWWA C605 Section. 7: Preparation for use.
10. Ductile Iron pipe hydrostatic pipe testing shall be done in accordance with section C600: Installation of Ductile-Iron Water Mains and Their Appurtenances. Previously described procedures for hydrostatic testing is for Polyvinyl Chloride (PVC) pipe only.

3.03 PIPE SCHEDULE

A. PVC Pipe:

1. Pipe sizes 4" or less, ASTM 2241, PVC 1120, SDR-21 pressure class 200 psi.
2. Pipe sizes 4” through 12”, AWWA C900, SDR 14, pressure class 200 Or Engineer acceptable alternate:

B. Ductile Iron Pipe: Pipe sizes 3” through 12”, pressure class 350 psi.

C. End connections to be push-on joints unless otherwise indicated on the Drawings.

D. Repair and/or replacement of existing water lines damaged during construction: Material generally to match existing or at least quality required by this section.

E. Provide sizes as shown on the Drawings.

3.04 VALVE SCHEDULE

A. Resilient wedge gate valves: as shown on the Drawings.

B. Provide sizes as shown on the Drawings and as provided for in the Bid Schedule.

END OF SECTION

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SECTION 33 3000

SANITARY SEWER UTILITIES

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. All sanitary sewer work and materials in this Section shall be performed in accordance with the Contract Drawings and the NMAPWA Construction Standards and Specifications, Latest Edition, including all updates, and all applicable laws, codes, and regulations.

B. Generally include but not be limited to furnishing all necessary material, labor, and equipment to construct the following:

1. Installation of the building sanitary sewer lateral(s)
2. Installation of precast concrete septic tank and distribution box

C. Trench excavation, backfill, and compaction shall be performed in accordance with Section 31.00.00 of these specifications.

D. All pipe shall be installed in an uphill direction where possible beginning at the lowest elevation. In the event that the Contractor wishes to deviate from this, sufficient elevation checks shall be made of the eventual downstream terminus points and approval shall be obtained from the Engineer prior to beginning work.

1.02 SUBMITTALS

A. The Contractor shall submit manufacturer specifications, catalogue cut sheets, and/or material samples to the Engineer for approval prior to construction. This shall generally include but not be limited to the following:

1. Polyvinyl chloride pipe
2. Precast concrete manholes, tanks and boxes
3. Access Manway frames and grates

PART 2 - PRODUCTS

2.01 PIPE

A. Sanitary sewer pipe shall be made of polyvinylchloride (PVC) and sized as shown on the Contract Drawings. The pipe shall be rated SDR 35 and conform to the requirements of ASTM D-3034. Joints shall be push-on rubber gaskets according to ASTM D-3212.

2.02 FRAMES AND COVERS

A. Castings for frames and covers shall be made of grey iron conforming to the sizes and types shown on the Contract Drawings.

B. Castings for catch basins shall meet requirements for AASHTO M105, Grade 30 and be free of cracks, casting faults, or other composition defects. Castings shall be furnished with burrs ground off at foundry.

C. Frames and grates for sanitary manholes shall be bedded on mortar to prevent movement or "rocking".

D. Covers shall be stamped “SEWER” on the top to indicate manhole type.

2.03 PRECAST CONCRETE STRUCTURES

A. Sanitary manholes, septic tanks and boxes shall conform to the sizes and types shown on the Contract Drawings.

B. Sanitary manholes, septic tanks and boxes shall be precast steel reinforced concrete with monolithic base fabricated in conformance with ASTM C478. The reinforced steel shall conform to the latest ASTM A185 Standards.

C. Rubber gasket seals shall be provided between each precast concrete riser to ensure a watertight seal.

D. Rubber boots or mechanical seals such as LINK SEAL as manufactured Thunderline Corp., Belleville, MI, or approved equal, shall be provided at all cutouts for pipe inverts to provide a positive watertight seal.

2.04 PIPE BEDDING AND TRENCH BACKFILL MATERIALS

A. Bedding Material is specified in Section 31 00 00 of these specifications.

B. Backfill Material: Backfill material shall be placed above the pipe bedding to subgrade elevations. This material shall be on-site soil, free of organics, wood, metals, cobbles greater than 6 inches, and deleterious materials, and shall be subject to the approval of the Engineer.

PART 3 - EXECUTION

3.01 TRENCH EXCAVATION

A. Trenching operations shall be performed in accordance with Section 31 00 00 of these specifications.

3.02 PIPE INSTALLATION

A. Pipe shall be installed with the bedding details given on the Contract Drawings and as specified in accordance with Section 31 00 00 of these specifications.

B. The pipe shall be delivered, stored, handled, lifted, and laid in the prepared excavation in accordance with the manufacturer's recommendations. The elevations of the pipe shall not vary more than 1/2 inch from the elevations indicated on the Contract Drawings.

C. Inlet structures shall be constructed as shown on the Contract Drawings. The elevations of the inverts and tops of the structures shall not vary more than 1/2 inch from the proposed grades.

D. Pipes entering and exiting the sanitary manhole shall be neatly cut flush with the inside of the manhole. Irregularities and rough edges inside the manhole shall be pointed with non-shrink grout.

E. Channels across the floor of the sanitary manholes shall be shaped to provide for smooth flow between pipe inverts. Concrete and mortar shall be used to obtain a channel having a smooth, fine textured surface.

F. Frames shall be embedded in mortar and bear uniformly on the structure such that there is no movement or "rocking".

3.03 BEDDING AND TRENCH BACKFILL PLACEMENT AND COMPACTION

A. Trench, backfill and compaction shall be performed in accordance with Section 31 00 00 of these specifications.

3.04 SURVEYING

A. The Contractor shall provide adequate survey controls to construct the utility to the lines and grades shown on the Contract Drawings. Elevations of pipe inverts and structures shall not vary more than ½ inch from specified elevations. Deviations from the plans will be permitted only with the approval of the Engineer.

B. An "As-Built" record shall be kept during construction showing the actual locations and grades. A copy of the as-built plan shall be submitted to the Engineer and Owner at the completion of the work.

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3.05 CLEANING INSPECTION AND TESTING

A. The Contractor shall cooperate with the Engineer as required to facilitate testing and inspection of the work. The Contractor shall clean and "lamp" the lines under the inspection of the Engineer before final acceptance of the work by the Owner.

B. The Contractor shall provide necessary materials, equipment, and labor to perform the tests as described herein.

C. The sanitary sewer lateral shall be tested for exfiltration.

D. Exfiltration

1. The Contractor shall provide a leakage test using the "Low Pressure Air Test" method. Prior to the acceptance test, the Contractor shall have cleaned the pipeline. The Contractor shall furnish test plugs, air compressor, and personnel for conducting the test. Pipe shall be plugged between two manhole locations. Air shall be slowly supplied to the plugged pipe installation until the pressure reaches 5.0 psi. A minimum time of two minutes shall be allowed for temperature stabilization.

2. The air supply will then be cut off. The rate of air loss shall then be determined by measuring the time interval for the pressure to drop from 4.5 to 3.5 psi. Test gages shall be graduated to the nearest 0.10 psi.

3. The pipeline shall be considered acceptable when the time interval for the pressure drop from 4.5 psi to 3.5 psi exceeds the corresponding allowable times given in the following table:

MINIMUM ALLOWABLE PIPE DIAMETER (inches)	**TIME INTERVAL (minutes: Seconds)**
6	2:15
8	4:00
10	4:45
12	5:40
15	7:05
18	8:30

E. The Contractor shall maintain the pipe and structures in clean working condition until final acceptance by the Owner.

END OF SECTION

SECTION 33 4000

STORM DRAINAGE UTILITIES

PART 1 GENERAL

1.01 WORK INCLUDED:

A. Work of this Section shall consist of the construction of storm sewer systems in substantial compliance with the specifications and the lines and grades shown on the plans.

1.02 RELATED SECTIONS:

A. Earthwork: SECTION 31 00 00

B. Flexible Paving : SECTION 32 12 00

1.03 QUALITY ASSURANCE:

A. All work and materials shall be in full accordance with the New Mexico Standard Specifications for Public Works Construction, Latest Edition, including all updates, and all applicable laws, codes, and regulations.

PART 2 PRODUCTS

2.01 STORM DRAINAGE SYSTEM:

A. Reinforced Concrete Pipe: Comply with requirements of ASTM C 76, Class III, unless otherwise indicated on Drawings, and install with rubber gasketed joints complying with ASTM C 443. Install rubber gaskets in strict accordance with pipe manufacturer's recommendations.

B. Polyvinyl Chloride (PVC) Pipe: Only permitted when pipe diameter is 12" and smaller and must meet requirements of ASTM D 1784. Pipe and fittings shall comply with ASTM D 3034, rated SDR 35. Pipe shall be continually marked with manufacturer's name, pipe size, cell classification, SDR rating, and ASTM D 3034 classification. Pipe joints shall be integrally molded bell ends in accordance with ASTM D 3034, Table 2, with factory supplied elastomeric gaskets and lubricant meeting ASTM F477.

C. High Density Polyethylene Pipe (HDPE):

1. Acceptable manufacturer: Hancor or ADS. Use of HDPE requires a pre-construction meeting with manufacturers representative to ensure proper installation practices are understood and used by contractor. Contractor shall notify engineer, in writing, the date and time of the completion of this meeting.
2. Pipe must be smooth interior, with a manning's n value not greater than 0.013.
3. HDPE shall use bell & spigot, with water-tight type joints.
4. HDPE shall conform with the following specifications:
    a. ASTM F 405 - Standard Specifications for Corrugated Polyethylene Pipe and Fittings
    b. ASTM F 667, Standard Specifications for Large Diameter Corrugated Polyethylene Pipe Fittings.
    c. ASTM D 1248.
    d. ASTM D 2321, Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity Flow Applications.
    e. ASTM D 3212, Standard Specification for Joints for Drain and Sewer Plastic Pipe Using Flexible Elastomeric Joints.
    f. ASTM F 1417, Standard Test Method for Installation Acceptance of Plastic Gravity Sewer Lines Using Low-pressure Air.

g. ASTM F 477-95, Elastomeric Seals (Gaskets) for Joining Plastic Pipe.

h. ASTM F 667, Standard Specification for Large Diameter Corrugated Polyethylene Pipe and Fittings.

PART 3 EXECUTION

3.01 EXCAVATION AND BACKFILL:

A. Trenches shall be excavated in accordance with the requirements of the New Mexico Standard Specifications for Public Works Construction and to a width sufficient to allow for proper joining of the pipe and thorough compaction of the bedding and backfill material under and around the pipe. Where feasible, trench walls shall be vertical (only as permitted by OSHA). The completed trench bottom below the bedding shall be firm for its full length and width.

B. When RCP is used backfill shall conform with the requirements of the (1) geotechnical report and (2) the New Mexico Standard Specifications for Public Works Construction.

C. When HDPE is used backfill shall conform with the requirements of the Manufacturer's Specifications.

3.02 LAYING PIPE:

A. Pipe laying shall begin at the downstream end of the pipe line except for extensions of existing pipes. The bottom of the pipe shall be in contact with the shaped bedding throughout its full length. The bell or grove (female) ends of rigid pipes and outside circumferential laps of flexible pipes shall be placed facing upstream. Flexible pipe shall be placed with longitudinal laps or seams at the sides.

3.03 JOINING PIPE:

A. Pipe joints shall be bell & spigot type joints. The method of joining pipe sections shall be such that the ends are fully entered and the inner surfaces are reasonably flush and even.

B. Joints shall be made using rubber gaskets as provided by the pipe manufacturer for the purpose of joining the pipe.

C. Mortar joints shall only be used were specifically authorized by the architect or engineer, and then shall be made with an excess of mortar to form a bead around the outside of the pipe and finished smooth on the inside.

3.04 TESTING:

A. Pipe shall be inspected before any backfill is placed. Any pipe found to be out of alignment, unduly settled, or damaged, shall be taken up and re-laid or replaced at no additional expense. Pipe testing shall be performed in accordance with New Mexico Standard Specifications for Public Works Construction.

B. All leaks or other defects which develop under the test shall be corrected by the Contractor at his expense. The test shall be repeated until all leaks or other defects have been eliminated.

END OF SECTION

DZILTH-NA-O-DITH-HLE COMMUNITY SCHOOL

SUPPLEMENTAL TECHNCIAL PROVISIONS

TECHNICAL PROVISIONS

The following sections of the Albuquerque Area- Indian Health Service/Office of Environmental Health and Engineering (AAIHS/OEHE)-Sanitation Facilities Construction (SFC) Technical Provisions, February 2016.

SECTION	TITLE/DESCRIPTION
SECTION 01	TRENCH EXCAVATION & BACKFILL FOR PIPELINES AND APPURTENANT STRUCTURES
SECTION 02	CONCRETE
SECTION 03	REINFORCING STEEL
SECTION 06	GRAVITY SANITARY SEWERS
SECTION 40	SEWAGE TREATMENT LAGOON CONSTRUCTION

ADDED TECHNICAL PROVISIONS

SECTION 11375	FLOATING AERATORS

TECHNICAL PROVISIONS

SECTION 01 - TRENCH EXCAVATION & BACKFILL FOR PIPELINES AND APPURTENANT STRUCTURES

TP-101 SCOPE:

Excavation, as used in these specifications refers to all construction activities necessary to install subsurface utilities in accordance with the plans and specifications. Such activities include, but are not limited to:

All necessary clearing, grubbing and site preparation; removal of all materials that may interfere with construction activities (except existing pipe work, conduits, utility structures or other items to be left in place) to the lines and grades indicated on the plans and otherwise described herein. The Contractor shall remove all construction trash from the site and transport to a legal disposal site.

Removal and/or storage of subsurface materials from trench and construction excavation areas to allow installation of designated utilities or structures. All suitable material removed from excavations shall be used, insofar as practicable, in the formation of embankments, fills and backfilling.

Preparation of sub-grades and backfilling of trench and construction areas upon completion of utility or structure construction.

All necessary bracing, shoring and protection (but not including tight sheeting in trenches and structure excavation ordered left in place by the Owner or Owner's Representative).

Final grading, dressing and cleanup of the construction site.

TP-102 SAFETY:

All trench excavation shall be coordinated in strict accordance with current OSHA requirements found in the Occupational Safety and Health Standards - Construction Standards for Excavations (29 CFR 1926, Subpart P).

Trenches shall be properly sheeted, shored, or sloped in accordance with the current OSHA standards. Trench excavation shall not proceed more than 500 feet in advance of pipeline work without the Owner or Owner's Representative's approval. All trenches shall be completely backfilled at the end of each working day, unless otherwise approved by the Owner or Owner's Representative. No excavation shall be left open without proper barricades and warning lights. Such devices shall conform to the Manual of Uniform Traffic Control Devices (ANSI D6.1) or such permits as are appended to these specifications.

The contractor shall be responsible for safety on the job site and shall designate a trained "competent person" knowledgeable in trench safety to supervise the work.

TP-103 SHORING AND SHEETING SYSTEMS:

Protection of employees in excavations shall conform to applicable OSHA Standards. Any trench protection and modification to trenching safety plans shall be submitted to the Owner or Owner's Representative in writing to be maintained as part of the record.

The Contractor shall install all shoring and sheeting systems required to prevent cave-ins and protect his employees and adjacent property and structures in accordance with current OSHA standards. No extra payment will be made for these items, the cost thereof being merged with and considered a part of the cost for the related excavation.

Before sheeting is withdrawn, or trench boxes moved forward, they shall be raised, in place, just above the pipe crown to safely allow the Contractor to completely fill any voids left in the pipe zone.

TP-104 ROAD, RAILROAD AND SPECIAL UTILITY CROSSINGS (IF REQUIRED):

The Contractor shall be responsible for compliance with all requirements of special crossing permits applicable to this project. Copies of such permits shall be included in the Appendix of these specifications. If no special crossing permits are appended, and such crossings are indicated on the plans, crossings will comply with all applicable provisions of Section 11 of the Technical Provisions in addition to those indicated under other provisions of this Section. At least two days notice shall be given to the Owner or Owner's Representative before work is done on any crossing.

TP-105 WORK WITHIN RIGHT-OF-WAYS & TRAFFIC CONTROL

When performing any work within the right-of-way of roads or railroads, the Contractor shall comply with the right-of-way permit for the installation including all of the requirements for traffic control and compaction. All work within the right-of-way of roads shall be performed in accordance with the "Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects FP-03 U.S. Customary Units – Section 614." All work within the right-of-way of roads shall be performed in accordance with the latest edition of the Manual on Uniformed Traffic Control Devices (MUTCD)." In addition, the Contractor shall submit a traffic control plan to the project engineer for review and approval prior to any work within the right-of-way of any roads or railroads.

TP-106 DRAINAGE:

The Contractor shall control the grading in the vicinity of the excavation so that the ground surface is properly sloped to prevent water from running into the excavated areas. Water that has accumulated in the excavation from rainfall and/or surface runoff, or from any other cause which might have been prevented by proper care and foresight, shall be removed and the subgrade restored to its proper bearing capacity, all at the Contractor's expense.

TP-107 EXCAVATION:

A. General: All excavation, other than by drilling and blasting, undertaken with the excavation equipment commonly used in the industry for this type of excavated material shall be classified as common excavation.

All excavation shall be made by open cut method except as approved or specified. During excavation, materials suitable for backfill shall be neatly piled no closer than 24-inches from the edge of the excavation. All materials not required or not suitable for backfill shall be removed and wasted at locations designated by the Owner or Owner's Representative.

1. Width: The sides of all trenches for the installation of utility piping systems shall be as nearly vertical as soil conditions will permit from ground level to the pipe. Except for the trenching of 1-inch water service lines, the width of the trench shall not be less than 16-inches nor more than 24-inches wider than the outside diameter of the pipe barrel. Trench excavation shall be centered on pipe alignment such that a minimum clear space of 8-inches is provided on each side of the pipe. Trench width above the level of the top of the pipe may be as wide as necessary for shoring or sheathing and for proper installation of the work.

2. Depth: The trench shall be excavated to the depth that permits pipe to be laid at the elevations shown on the engineering drawings or with the required depth of cover specified by the Owner or Owner's Representative. Depth of cover shall be measured from the finished grade or the surface of the permanent improvement to the top of the pipe barrel.

3. Preparation: The bottom of the trenches shall be accurately shaped to line and grade and shall provide uniform bearing and support for each section of the pipe on specifically placed bedding material at every point along its entire length. Bell holes and depressions for joints shall be dug after the trench bottom has been graded and shall be only of such length, depth and width as required for properly making the particular type joint. Care shall be taken not to excavate below the depths indicated. Unauthorized over depths shall be backfilled with suitable bedding material at the Contractor's expense.

4. Previous Excavation: If the trench passes over a sewer or other previous excavation, the trench bottom shall (1) be compacted to provide support equal to that of the undisturbed native soil or (2) conform to the specific regulatory requirements that preclude damage to the existing installed facility.

5. Unstable Subgrade: Where soft, spongy or otherwise unsuitable material is encountered, which will not provide a firm foundation for pipe, the Owner will direct the extent to which removal and replacement shall be made with suitable material. Special pipe foundation material is NOT anticipated. However, if required, a price shall be negotiated between the Owner and Contractor for special pipe foundation material.

6. Underground Obstructions: The Contractor shall preserve intact any underground pipes, culverts or other utilities encountered during construction (except as hereinafter permitted) provided their location is such that they do not interfere with new pipelines or structures being installed. The Contractor shall notify all appropriate utility authorities of his construction schedule so they may be at the site to locate and protect their property. If any utilities or structures are accidentally broken or disturbed, they shall be replaced immediately to a condition at least equal to that in which they were found, all at the Contractor's expense. Couplings used to repair water service lines shall be brass compression couplings and couplings used to repair sewer service lines shall be solid sleeve couplings that provide a rigid connection between pipes. The repair work shall be done in a manner acceptable to the Owner or Owner's Representative and the utility company. Any existing water or sewer services that will intersect or interfere with the new pipelines or structures shall be rerouted by the Contractor in the manner indicated by the Owner or Owner's Representative. Existing water or sewer services from the mains to private property that interfere with trenching operations may be cut and replaced at the Contractor's option and expense, provided that users of such services are notified at least 2 hours in advance and that the use of such service shall in no case be interrupted for more than 4 hours, unless specifically permitted in writing by the user. Materials and construction for these items shall be as provided in other sections of these specifications. All new and existing water and sewer mains and water and sewer services shall be protected from freezing at all times during construction.

B. Rock: The inclusion of a bid item and estimated quantity for rock excavation in the bid schedule indicates that rock excavation is probable. However, the exclusion of this item from the bid schedule does not preclude the possibility that rock will be encountered; it merely indicates that it is not anticipated. If unanticipated rock is encountered, the Owner or Owner's Representative will negotiate a price for rock excavation with the contractor. The following paragraphs define solid rock and loose rock excavation.

Solid rock shall be defined as large masses of igneous, metamorphic, or sedimentary rock that, in the opinion of the Owner or Owner's Representative, cannot be

excavated without drilling, blasting, or the use of rippers or other specialized equipment. Any material excavated without the use of blasting or specialized ripping equipment shall not be considered rock.

Solid rock excavation shall be measured in cubic yards from the top of the rock to a point 4-inches below the invert of the installed pipe and an assumed 24-inches trench width, regardless of the actual trench width and depth excavated. For structures, the rock shall be profiled 12-inches outside the perimeter of the structure and computed based on a product of the profile of the rock and an assumed 24-inches outside the structure's perimeter and 6-inches below the structure's footing. The rock volume will be computed as the product of the profiled rock area, as measured by the Owner or Owner's Representative. The measurements shall be within the nearest 0.1-feet from the surface and no less than every 10-feet by one of the following methods:

1. Excavating and exposing the rock profile for measurement. This shall be the responsibility of the contractor and no additional payment shall be made for this excavation.

2. Rock profile determined by drilling without excavating and measurements taken prior to any blasting.

3. Rock profile measured after blasting and excavation. A 20% deduction shall be made in rock determination when this method is used to allow for expansion in ledge due to blasting.

Loose rock shall be defined as boulders and other detached stones each having a volume of 1 cubic yard or more. Loose rock shall be removed from the excavation in such a way that a clear distance of at least 4-inches exists between the rock and the bottom of the pipe and 6-inches exist between the rock and the bottom structure. Loose rock shall not be used for backfill. Loose rock excavation shall be measured in cubic yards, including the total volume of only those rocks or boulders that are individually over 1 cubic yard in volume.

Trench in which rock is encountered shall be excavated at least 4-inches deeper than the pipe invert and refilled to the required elevation with sand , gravel, or crushed rock passing a 3/4-inch mesh screen. Bedding material shall extend upward at least 12-inches above the pipe. Payment for this fill material shall be considered incidental to the rock excavation and no additional payment shall be made.

Should rock excavation be encountered, it shall be the responsibility of the Contractor to have an experienced powderman handle all blasting and be able to furnish proof of his/her credentials. The Contractor shall also inform all residents in the vicinity of proposed blasting activities and shall be responsible for any damage to persons or property as covered in the General Provisions.

C. Removal of Water: The contractor shall remove and dispose of all water entering the trenches and shall keep the trenches water free until the facilities are in

place and sealed against the entrance of water. Use of a trash pump for removal of nuisance water shall be at no extra cost and shall not be considered dewatering. In no case shall water, earth, or any foreign materials be allowed to enter the water main or sewer lines.

The removal of nuisance water is determined by pumping the water out of the trench with a heavy-duty 4" construction trash pump with a strainer for a minimum of 1 hour. The strainer shall be placed in a bed of pea gravel or a slotted PVC pipe in order to screen the debris.

All water removed from trenches shall be conveyed to natural drainage channels, storm sewers, or proper reservoirs as approved by Owner or Owner's Representative. Such removal of water shall be in a manner that prevents property damage, erosion, or sedimentation.

The inclusion of a bid item and estimated quantity for dewatering in the bid schedule indicates that dewatering is probable. However, the exclusion of this item from the bid schedule does not preclude the possibility that water will not be encountered, it merely indicates that it is not anticipated.

If continuous pumping with well points is required to maintain a satisfactory trench, and the contractor is so directed by the Owner or Owner's Representative, this work shall be considered as dewatering. Well points shall be set separately for each trench being dewatered. Dewatering shall be based on the actual number of lineal feet of trench dewatered and paid for at the negotiated price between the contractor and Owner or Owner's Representative.

D. Structural Excavation: Excavation for structures shall extend a sufficient distance from walls and footings to provide for forming, except where concrete for walls or footings is authorized to be deposited directly against excavated surfaces. Care shall be taken to avoid excavating below the depths indicated in the plans. Over-excavation shall be restored to proper elevation by filling with suitable granular bedding material at the Contractor's expense.

TP-108 BACKFILLING:

A. General: Trenches shall not be backfilled until the Owner or Owner's Representative has inspected and approved the pipe installation and jointing as being in compliance with the requirements of plans and specifications.

Bedding and backfill materials to a depth of 12-inches above the pipe shall be carefully deposited in layers not more than 6-inches thick, loose measurements, wetted to optimum moisture content and hand or mechanically compacted to at least 95% of the reference density for this material as described in the specification titled "Compaction Requirements, Methods and Testing. From 12 inches above the pipe to

ground surface, the excavation material shall be placed in layers not to exceed 12-inches, mounded and left in a uniform, neat condition.

Wherever trenches have not been properly filled, or if settlement occurs, they shall be reopened to the depth required for proper compaction and refilled and re-compacted as specified above and approved by the Owner or Owner's Representative.

Compaction methods and equipment may utilize hand and mechanical tampers and rollers. The equipment and procedures proposed by the Contractor shall be subject to the approval of the Owner or Owner's Representative.

B. Materials: All backfill material shall be approved in advance of installation by the Owner or Owner's Representative. Materials shall be obtained from areas approved by the Owner or Owner's Representative.

Backfill material will not be paid for separately, but shall be considered as subsidiary to and a part of the cost for the applicable contract bid item.

1. Embedment: Embedment is that material from the bottom of the trench to twelve inches above the pipe, and includes the pipe bedding material (upon which pipe is layed), haunching material (extending from pipe bottom to pipe centerline), and initial backfill material (extending from pipe centerline to 12 inches above pipe). Native soil used for embedment must be free from clods of earth or stones larger than 1 inch in any dimension, organic refuse, debris, frozen soil, and other objectionable material. If the native soil does not meet these criteria, the Contractor shall screen it (as applicable) or import special bedding material.

2. Imported Special Bedding Material: If required, special bedding material shall consist of sand, sandy gravel, or other suitable granular material having a maximum plasticity index of 6, with 100% of the bedding material smaller than 3/4-inches, and no more than 5% passing a No. 200 sieve.

3. Stabilization: Granular stabilization material shall be used to replace soft, spongy, or other unsuitable material, including rock encountered in excavation, to the depths necessary to support the pipe or structure. Stabilization materials shall be underlay bedding material (as applicable) and shall consist of suitable hard, durable granular material having a maximum size of 6-inches, graded so that a maximum of 20% passes a No. 4 sieve. Granular stabilization is not anticipated. If required, a price for granular stabilization shall be negotiated between the Contractor and the Owner.

4. Final Backfill: In general, final backfill will be that material originally excavated from the trench and will extend from 12 inches above the pipe to surface grade. Final backfill material shall be the same as that around the pipe except that the inclusion of a limited amount of stones up to 6-inches in diameter will be permitted.

C. Placement:

1. Embedment: Embedment shall be placed in 6-inch loose lifts and compacted as described herein. If over-excavation is required, bedding material is to be compacted to 95% of the maximum dry density as determined by the Standard Proctor density test (ASTM D-698). Haunching material shall be placed by hand and worked under the pipe haunch to provide adequate side support for the pipe. Haunching and initial backfill material shall be compacted to 95% of the maximum dry density as determined by the Standard Proctor density test (ASTM D-698).

2. Final Backfill: Final backfill shall not be placed until the embedment material is placed and compacted, and the Owner or Owners Representative have inspected and approved the installation. Final backfill shall be placed in lifts not to exceed 12-inches unless otherwise approved by the Owner or Owners Representative. Compaction shall be as defined in the Compaction Requirements, Methods, and Testing section.

3. Backfill for Road Subgrade: Under existing and proposed roadways, to a distance of 10-feet on either side of the road, bedding and backfill materials shall be carefully deposited in layers not more than 6-inches thick, loose measurements, wetted to optimum moisture content and mechanically compacted as described in the Compaction Requirements, Methods, and Testing section.

4. In areas where pavement is to be replaced, or in roads that are to be paved, no rocks or stones that will interfere with subgrade preparation shall be included in the backfill within 12-inches of the finished subgrade elevation. The upper 12-inch layer, forming the subgrade for pavements, shall be compacted to a density of at least 95% (ASTM D-698 - Modified Proctor Test). See Section 11 of the Technical Provisions where this is required.

5. Cement slurry can be substituted for compacted native backfill and subgrade if approved by Owner or Owner's Representative. The cement slurry shall consist of one sack of cement to one cubic yard of concrete sand and shall be placed from the concrete truck at a slump of 6 to 8 inches. Steel plates 5/8" thick are to be placed over the trench with at least 6 inches overlap on each side and edged with asphalt to prevent traffic movement. The backfill shall be allowed to set for a minimum of 12 hours before completing the asphalt patch. Slurry can typically be installed from the trench bottom to ground surface and no intermediary subgrade material is required for placement of asphalt patch.

6. Where trenches cross roads, streets, or driveways, backfilling shall be completed immediately following excavation and inspection. No trenches across roads shall remain open overnight. All crossings shall be backfilled, compacted and open to traffic at the end of each day's work. Major road crossings shall be excavated and backfilled in half widths of the traveled way so that at least one-half of the roadway is open to controlled traffic at all times during the work.

7. Backfill Around Structures: Backfill around structures shall conform to the same requirements as those for backfill around piping in unpaved areas, unless more stringent requirements are indicated in other sections of these specifications.

TP-109 COMPACTION REQUIREMENTS, METHODS, AND TESTING:

A. Minimum Density: Unless otherwise specified by applicable permits initial and final backfill and gravel resurfacing shall be compacted to the following minimum requirements. The minimum acceptable percent of compaction is the in place dry density divided by the reference density times 100. Compacted soil shall also be at plus or minus 2% of optimum moisture content.

TYPE	LOCATION	REQUIRED COMPACTION
I	Under any existing or proposed pavement, curb Gutter, sidewalk, roadway, shoulder, alley, slab, Footing, canal embankment, or when within 2 feet of above.	95%
II	Within any gas, electric, or telephone utility easement, Or within any street or road right-of-way outside the limits defined above as Type I.	90%
III	All other locations not defined above as Type I or Type II.	80% (or 100% of adjacent natural ground)

B. Reference Densities/Baseline Testing: The Contractor, at his expense, shall provide the reference densities for the various bedding and backfill materials used. All tests shall be performed by a certified soils testing laboratory approved by the Owner or Owner's Representative. If reference to natural ground is used, a nuclear gauge may be used to measure the density of the natural ground. The reference densities for compaction tests shall be established in accordance with ASTM D-698, Modified Proctor Test. The Contractor shall submit for approval a testing plan identifying proposed testing locations prior to the start of any excavation work.

Contractor shall provide copies of the Modified Proctor Tests with 5 point minimum moisture vs. density curves.

The contractor shall coordinate the collection of soil samples for proctor testing with the IHS construction inspector such that both parties are on-site during the collection of soil samples. This will ensure that enough samples are collected to provide for accurate density testing during construction by providing reference density for differing soil conditions within the project area.

C. Methods: Mechanical compaction is permitted. Water jetting methods are not permitted. The backfill shall be uniformly moistened to plus or minus 2% of optimum moisture content, placed in sufficiently thin layers to obtain the specified results, and compacted with hand and/or pneumatic tamp, roller, hydrohammer, or other device which will obtain the specified density without injury to the pipe or related structures.

D. Density Tests: Backfill density tests shall be performed in accordance with the latest versions of ASTM D-1556 (Sand Cone Method), ASTM D-2167 (Rubber Balloon Method), ASTM D-2216 (Moisture Content), ASTM D-2922 (Nuclear Density), and ASTM D-3017 (Nuclear Moisture Content). The Contractor will perform initial field density tests for each location listed in the next paragraph at the expense of the Contractor. Any additional tests due to failure of initial tests shall be at the expense of the Contractor.

The Contractor will perform at least one (1) compaction test every other lift at each two hundred and fifty (250) linear feet of Type I location. One compaction test will be performed every other lift on each five hundred (500) linear feet of trench at Type II or III locations. A minimum of one (1) compaction test shall be performed under each lift station base and a minimum of four (4) compaction tests shall be performed on each lift of material under proposed foundations or tanks. The exact test locations shall be specified by the Owner or Owner's Representative. The Owner may perform additional tests. If the results of any of the compaction tests indicate insufficient compaction, the area in question shall be reopened to a depth required for proper compacting, then refilled, compacted and retested, at the expense of the Contractor, until the compaction tests indicate that the necessary compaction requirements have been met. Two copies of the test results of any retesting performed by the Contractor shall be provided to the Owner, for approval, prior to any permanent surfacing. Any improperly placed backfill, or locations where settlement occurs, shall be reopened to the depth required for proper compaction, then refilled and compacted at the expense of the Contractor. The surface shall be restored and resurfaced, if necessary to the required grade.

TP-110 DISPOSAL OF EXCESS MATERIAL:

Excess material, including rock, broken concrete, bituminous materials, debris or other materials not suitable for backfill, shall be removed from the site and wasted in the disposal areas selected by the Contractor and approved by the Owner or Owner's Representative.

The disposal of such excess materials will not be paid for separately, but shall be considered as incidental to and a part of the cost for the applicable contract bid item.

TP-111 CLEANUP:

Upon completion of the work, the entire site shall be cleared of all debris, and ground surfaces shall be finished to smooth, uniform slopes and shall present neat and workmanlike appearance. All slopes shall be trimmed and dressed, and all surfaces graded such that effective drainage is assured.

Unpaved streets shall be graded smooth to the satisfaction of the Owner or Owner's Representative.

TP-112 TRENCH MAINTENANCE:

The Contractor shall, for a period of one year after completion and final acceptance of the work, maintain and repair any trench settlement that may occur and shall make suitable repairs to any pipe, pavement, or other structures that may become damaged as a result of backfill settlement.

TP-113 STORM WATER POLLUTION PREVENTION PLAN (SWPPP):

The Contractor shall prepare a Storm Water Pollution Prevention Plan (SWPPP) in accordance with the latest requirements of the Environmental Protection Agency's (EPA) National Pollutant Discharge Elimination System (NPDES) General Permit for Discharges from Large and Small Construction Activities. The SWPPP must be prepared in accordance with good engineering practices and must 1) Identify all potential sources of pollution which may reasonably be expected to affect the quality of storm water discharges from the construction site; 2) Describe practices to be used to reduce pollutants in storm water discharges from construction site; 3) Assure compliance with the terms and conditions of the NPDES General Permit.

If the Contractor is not experienced in the preparation of SWPPP, the contractor shall retain the services of an environmental firm regularly engaged in the preparation of

SWPPP to perform said service. The completed SWPPP must be approved by the Owner or Owner's Representative at least 14 calendar days before the start of construction so that a Notice of Intent can be sent to EPA.

The Contractor shall fully implement the SWPPP from the commencement of construction until final stabilization, as defined in the NPDES General Permit is achieved.

The Contractor shall maintain and update the SWPPP, as required in the NPDES General Permit, for the life of the project. Updates shall include amendments required as a result of the ineffective controls discovered through the course of inspections or investigations conducted by the Owner or Owner's Representative, site staff, or by local, state, tribal or federal officials. The Contractor shall submit a Notice of Intent to EPA to obtain permit coverage, modify the coverage as necessary, and terminate permit coverage once final stabilization is achieved.

TP-114 LINES AND GRADES:

The Engineer will give all lines, grades and building locations on the plans and will supply the contractor with the AutoCAD drawing to stake out the facilities to be installed. The CONTRACTOR shall be responsible for staking out pipeline centerlines with a lath every 200 feet or line-of-sight whichever is less. Bends, intersections, manholes, lift station centers and fence corners shall be staked by the CONTRACTOR and provided with two offsets for alignment. Elevation references will be provided as shown on the plans, at lift station and for sewer manholes. The Contractor shall be responsible for the preservation of the location and line and grade stakes when set, and if disturbed, shall have such stakes replaced.

TP-115 CLEARING & GRUBBING:

It is the contractor's responsibility to clear and grub the site prior to or during construction. The contractor shall remove all trees along the water and sewer main alignments. Trees may either be chipped with a woodchipper and placed over the trench for erosion control or disposed of at the Contractor's expense. Clearing and grubbing shall be done at the contractor's expense.

TP-116 SEEDING:

All disturbed areas shall be returned to their pre-construction vegetative state. The contractor shall submit a seed mix that is equivalent to the native vegetation in the

area of construction. The contractor shall protect the seed after it is placed with hay mulch, straw mulch, wood cellulose mulch, or as approved by the project engineer. A minimum of 20 pounds of seed per acre shall be placed. Seed shall be placed by either drill seeding at a depth of approximately 1 inch or broadcast seeding. If broadcast seeding is utilized, the contractor shall apply twice the minimum seeding rate (40 pounds of seed per acre). The contractor shall perform maintenance as needed to ensure that adequate vegetative growth and stabilization has taken place to minimize erosion after construction is completed.

TP-117 FROST PROTECTION:

A. Materials: The insulation shall be rigid extruded polystyrene insulation board, having a minimum compressive strength of 25 psi. The width shall be 2 feet for mains, service lines and effluent discharge lines less than 6-inches (nominal diameter). The thickness shall be 2-inches.

B. Placement: When indicated on the drawings and in the bid schedule, insulation shall be placed in areas where water lines, sewer lines, or effluent discharge lines are susceptible to freezing. The insulation shall be centered over the main with no more than 6 inches of compacted fill between the pipe and insulation. The Contractor shall grade fill so insulation lays flat and maintain a straight alignment of insulation. The Contractor shall lap insulation by 6 inches or stagger by 6 inches if composed or two layers. The thickness for the first lift of backfill over the insulation shall be a minimum of 8 inches. The Contractor shall not operate construction equipment directly on insulation and not compact the first lift with the backhoe-mounted compactor, or any other large compaction equipment. The remaining backfill shall be compacted using normal construction practices.

TP-118 REPAIRS TO DAMAGED UTILITIES

The contractor is responsible for repairing any utilities that they damage during construction at no cost to the Owner. Repairs shall be made in accordance with the requirements of each utility. Below are the requirements for making repairs to damaged water and sewer utilities.

Water Mains: If the damage is small a small crack or hole in the water main, the contractor shall install a stainless steel repair coupling equal to a Romac SS1, SS2, or SS3. If the damage is too large to repair with a repair coupling, the Contractor shall install new water main to replace the damaged water main. The repair must result in a watertight water main that does not leak. The new water main shall be DR-18, Class 235, C900 PVC water main per TP-4. The new water main shall be connected to the existing water main using restrained joint solid sleeve couplings equal to

Romac Alpha series restrained couplings.

Water Service Lines: If the damage is small a small crack or hole in the water service line, the contractor shall install a stainless steel repair coupling equal to a Ford Small Repair Clamp with Full Wrap Gasket FSC. If the damage is too large to repair with a repair coupling, the Contractor shall install new water service line to replace the damaged water service line. The repair must result in a watertight water service line that does not leak. The new water service line shall be 200 psi rated polyethylene water service line meeting TP-5 requirements. The new water service line shall be connected to the existing water service line using stab joint, compression joint, or pack joint brass fittings as specified in TP-5.

Sewer Mains & Service Lines: If the damage is small a small crack or hole in the sewer main or service line, the contractor shall install a stainless steel repair coupling equal to a Romac LSS1, LSS2, or LSS3. If the damage is too large to repair with a repair coupling, the Contractor shall install new sewer main or service line to replace the damaged sewer main. The repair must result in a watertight sewer main or service line that does not leak. The new sewer main shall be SDR-35 PVC sewer main meeting TP-6 requirements and the new sewer service line shall be SDR-35 PVC sewer service line meet TP-7 requirements. The new sewer main or service line shall be connected to the existing sewer main using solid sleeve couplings equal to Romac 501 sewer couplings.

TP-119 AS-BUILT DRAWINGS:

A. General: The as-constructed drawings shall be a record of the construction as installed and completed by the Contractor. They shall include all the information shown on the Contractor's set of drawings and a record of all deviations, modifications or changes from those drawings, however minor, which were incorporated in the work, all additional work not appearing on the contract drawings and all changes which are made after final inspection of the contract work.

B. As-Built Drawings: The Contractor shall mark up one set of paper prints to show the As-Built Drawing information. These Asbuilt Drawing prints shall be kept current and available on the job site at all times. All changes from the contract plans which are made in the work or additional information which might be uncovered in the course of construction shall be accurately and neatly recorded as they occur by means of details and notes. No construction work shall be concealed until the necessary record data has been recorded. The Asbuilt Drawing marked prints will be jointly inspected for accuracy and completeness by the Owner and a responsible representative of the construction Contractor prior to submission of each partial payment, as evidenced by the issuance of a receipt by the Owner indicating the adequacy of the information. Failure to keep the as-constructed marked prints on a

current basis shall be sufficient justification to withhold approval of request for payment or suspend pay estimates. The drawings shall show the following information, but not limited thereto.

1. The location and description of any utility lines or other installations of any kind or description known to exist within the construction area. The location includes dimensions to permanent features.
2. The location and dimensions of any changes from the contract drawings.
3. Changes in details of design or additional information obtained from working drawings specified to be prepared and/or furnished by the Contractor including but not limited to fabrication, erection, installation plans, and placing details, pipe sized, insulation materials, dimensions of equipment foundations, etc.
4. All changes or modifications which result from the final inspection.
5. All information as required in the technical provisions.

C. Electronic/Surveyed As-built Drawings: The contractor shall obtain the services of a surveyor licensed in the State of New Mexico to survey in the locations of all sanitation facilities installed by the project being constructed. The number and location of surveyed points must be sufficient to provide enough detail to accurately identify the location of the installed sanitation facilities. Points to be surveyed shall include, but not be limited to:

Water Mains & Services: gate valves, fire hydrants, flush hydrants, water meters, air/vacuum release valves, water/sewer crossings, water main bends, water service line connection, water main intersections, casing pipe, water main reducers, and other water main components installed under this project.

Other Water Facilities: wells, booster pumps, valve vaults, building corners, fence corners, water tanks (including base and overflow elevations), and other water main components installed under this project.

Sewer Mains & Services: manholes (including rim elevation, invert in elevation, and invert out elevation), terminal sewer main cleanout rim and invert, sewer service cleanout, new sewer service line connection, and other sewer components installed under this project.

Other Sewer Facilities: lift stations (including base elevation, rim elevation, invert in elevation, lead/lag pump on elevation, all pump off elevation, and high/low alarm elevation), valve vaults, gate or plug valves, air/vacuum valves, building corners, fence corners, treatment tanks (including rim elevations, invert in elevations, and

invert out elevations), treatment units, lagoons (including floor elevation, top of berm elevation, and invert elevations of all piping in transfer structures), and other sewer components installed under this project.

The contractor shall furnish the Owner with electronic asbuilts of the facilities installed on this project in ACAD format (dwg file). The project engineer will furnish the contractor with an electronic copy of the contract drawings in ACAD format and will provide control points for use by the contractor to draft the electronic asbuilt drawings. The labeling, linework, and format of the electronic asbuilts shall be similar to that of the contract drawings.

D. Review and Approval: One set of the preliminary As-built Drawings marked prints shall be delivered to the Owner before final inspection for his review and approval. The review by the Owner will be expedited; however, the Owner cannot guarantee to review more than one complex mechanical or electrical Record drawing sheet per working day. Upon disapproval of the As-built Drawings one set of marked prints will be returned to the Contractor for further work and resubmitted to the Owner.

E. Other: All costs incurred by the Contractor in the preparation and furnishing As-built Drawings shall be included in the contract price and no separate payment will be made for this work.

TP-119 MEASUREMENT AND PAYMENT:

A. General: Except for the following items, the cost of all work done by the Contractor as required under Section 01 of the Technical Provisions shall be merged with the pay items defined within the Measurement and Payment portions of other Sections of this contract.

B. Rock Excavation: Payment for rock excavation shall be at the unit price listed in the Bid Schedule based on the computed number of cubic yards removed. No differentiation payment will be made between solid or loose rock excavations.

C. Dewatering: Dewatering shall be based on the actual number of lineal feet completed. Payment for dewatering shall be at the contract unit price shown in the Bid Schedule. This price shall be full compensation for furnishing all labor, equipment, materials, and incidentals required for a complete dewatering installation.

D. Mobilization/Demobilization: Payment for mobilization/demobilization shall be at the unit price listed in the bid schedule. 60% of this line item may be requested upon complete mobilization to the job site and the remainder may be requested upon demobilization from the job site.

E. Storm Water Pollution Prevention Plan: Payment for the preparation and implementation of the SWPPP shall be paid on a lump sum basis as shown on the Bid Schedule. Payment shall be full compensation for plan preparation including required revisions for Owner's acceptance, updates to the SWPPP for the life of the project, permit application, inspections, installation and maintenance of controls, modification of controls as determined by inspections, removal of pollutants due to failed controls, and permit termination.

F. Seeding: Seeding shall be paid for on a lump sum basis to seed the site in accordance with these specifications. Payment for seeding shall be at the contract unit price shown in the Bid Schedule. This price shall be full compensation for furnishing all labor, equipment, materials, and incidentals required for complete installation.

G. Exploratory Time: Exploratory time shall be measured on an hourly basis for an actual period spent on locating the existing utility line exceeding two hours. Contractor shall follow these steps:

1. Call the representative from the operating Utility and make every effort to locate the existing utility line prior to excavation.

2. Locate the existing utility line for two hours at the Contractor's expense.

3. If the Contractor is unable to locate the existing utility line within two hours, the Contractor shall notify the Owner or Owner's Representative and both agree upon a start time. The start time shall be recorded. When the Contractor locates the existing utility line, the end time shall be recorded.

If the Contractor fails to notify the Owner or Owner's Representative when the Contractor will start locating the existing utility line, the Contractor will not be compensated. Payment for exploratory time shall be at the contract unit price shown in the Bid Schedule. This price shall be full compensation for furnishing all labor, equipment, materials, and incidentals required for locating the existing utility line.

H. Frost Protection: Payment for frost protection shall be based on the actual number of lineal feet completed. Payment for frost protection shall be at the contract unit price shown in the Bid Schedule. This price shall be full compensation for furnishing all labor, equipment, materials, and incidentals required for a complete installation.

TP-120 APPROVALS:

A. Stabilization material, if required

B. Bedding material, if required

C. Rock excavation method, if required

D. Dewatering procedures, if required

E. Baseline Proctor density test results (5 point moisture density curves)

F. Baseline testing location plan

G. Soil Testing Lab Certification

H. Stormwater Pollution Prevention Plan, if required

I. Blasting contractor and credentials, if required

J. Seed Mix

K. Insulation, if required

L. Traffic control plan, if required

TECHNICAL PROVISIONS

SECTION 02- CONCRETE

TP-201 SCOPE

Furnish all labor, materials, equipment, and incidentals as required, and perform all operations in connection with the placement of concrete in accordance with the applicable drawings and these specifications.

TP-202 MATERIAL:

A. Cement: Portland cement shall conform to ASTM C150 Cement, Portland Type I, Type IA, Type II, Type IIA, Type III, or Type IIIA.

B. Aggregate: Aggregate shall be composed of clean, hard, durable, uncoated grains and crushed stone, free from detrimental amounts of clay, dust, soft or flaky particles, loam, shale, schist, slate, alkali, disintergrated stone, organic matter or other deleterious matter.

C. Water: All water used for concrete shall be of potable quality.

TP-203 CONCRETE REQUIREMENTS

Property		Minimum	Maximum
Cement Factor	(sacks per cu. Yd.)	6.0	---
Water-Cement Ratio	(gal. Per sack)	---	6.0
Entrained Air	(percent)	2.0	6.0
Slump	(inches)	1.0	4.0
Compressive Strength			
7 day	(psi)	1,800	
28 day	(psi)	3,000	

Concrete shall be uniformly plastic, cohesive and workable, i.e., can be placed without honeycomb and without voids in the surface. Workability shall be obtained without producing a separation of ingredients such that free water appears on the surface. In general, minimum amount of water required to produce a workable mixture shall be used.

TP-204 FREEZING WEATHER:

No concrete work shall be done if the air temperature is below 40 degrees ^{0}F, except with the approval of the Owner or Owner's Representative. If approval is given to work, the water and aggregate shall be heated to at least 80 degrees ^{0}F, before mixing.

In all cases where the air temperature is predicted to be below 40 degrees ^{0}F, the concrete shall be insulated for at least 72 hours by straw, blankets or other approved methods. No concrete shall be poured against frozen ground.

The use of salt or other compounds to prevent concrete from freezing shall not be permitted. Any work that has been injured by freezing shall be removed and replaced at the Contractor's expense.

TP-205 CURING:

Fresh concrete shall be adequately protected from heavy rains and mechanical injury. Concrete surfaces shall be kept moist by spraying with liquid membrane coating. Foundations and thrust blocks may be cured by covering with water saturated soil or backfill. All concrete shall be cured at least three days prior to stripping forms or structural loading.

TP-206 TRANSIT MIXED CONCRETE:

Ready-mixed concrete from a central batching plant and mixed in transit will be permitted with the Owner or Owner's Representative's approval. A plant batch certification sheet shall be provided by the concrete supplier listing the batch components for approval by the Owner or Representative.

TP-207 FIELD TESTING:

Four cylinders shall be taken for each 50 cubic yards of concrete placed or portion thereof. If the Owner or his/her representative suspects, by visual inspection, slump, or other tests, that any other concrete appears substandard, additional test cylinders shall be required. The Contractor shall provide cylinder molds at the construction site and shall have the cylinders tested by an approved laboratory, with the Contractor bearing all costs. If any test cylinder falls below 3000 psi at 28 days, this shall be sufficient cause to reject that portion of concrete. The Contractor shall remove and replace defective concrete with acceptable material at his own expense. The test cylinders shall comply with ASTM C31 for making and curing test specimens in the field. Additional information concerning testing is found in the SPECIAL PROVSIONS.

In addition, the contractor shall perform one slump test and one air entrainment test for each concrete truck.

Field testing will not be required for non-structural concrete placement such as pre-cast manhole bases, concrete collars, yard hydrant concrete pads, fence post concrete anchors, monitoring well

concrete pad, control panel concrete pad, cleanout collars, manhole collars, and drop manhole concrete encasements.

TP-208 PLACING CONCRETE:

Before placing concrete, the Contractor shall give 72-hour advance notice to permit proper inspection of forms and reinforcement by the Owner or Representative.

After completion of the mixing, the concrete shall be rapidly conveyed to and deposited in the forms. Consolidate the concrete, immediately after placing, by mechanical vibrating equipment, supplemented by hand-spading, roding, or tamping. Use equipment and procedures for consolidation of concrete in accordance with ACI recommended practices.

The concrete shall be placed in such a manner as to prevent excessive crawling and segregation of the aggregate. No concrete shall be used that has partially set before final placing, nor shall retempering of the concrete be permitted. All concrete shall be placed in the forms no more than 90 minutes after mixing.

TP-209 FORMS:

The Contractor shall provide forms that will produce correctly aligned concrete. The centering of the forms shall be true and rigid and thoroughly braced both horizontally and diagonally. Forms shall be sufficiently strong to carry the dead weight of the concrete as a liquid without deflection, and tight enough to prevent leakage of mortar. The inside of forms shall be coated with an approved oil or thoroughly wetted. The Owner or Representative shall be notified prior to removal of form work.

The final concrete structure shall be inspected for alignment, elevation, and concrete quality. Final concrete structure alignment and elevation shall be checked by use of land surveying instruments.

Should the concrete structure alignment, elevation, and/or quality test results be determined unsatisfactory by the Owner or Owner's Representative, the entire structure or parts of the structure will be rejected. All further alignment or elevation corrections, or any concrete removal and/or replacement, shall be at the Contractor's expense.

Honeycombed and void areas in the concrete shall be removed and patched to produce a sound concrete product by a method selected by the Contractor and approved by the Owner or Owner's Representative.

TP-210 MORTAR:

Mortar shall be made of one part masonry cement, three parts sand, and only a sufficient amount of water to make a workable plastic mix. Retempered mortar shall not be used.

TP-211 GROUT:

Grout shall be made of one part Portland cement, two parts sand, and only a sufficient amount of water to make a workable plastic mix. Retempered grout shall not be used.

TP-212 MEASUREMENT AND PAYMENT:

Concrete and other work or materials required by this section shall not be measured and paid separately. Rather, they shall be included in the unit or lump sum bid prices of those items shown on the Bid Schedule that require the inclusion of such materials or work, even if not specifically mentioned within the measurement and payment sections of those particular pay items.

TP-213 SUBMITTALS:

A. Concrete testing laboratory
B. Certification of concrete strength by the concrete supplier and/or proposed concrete mix
C. Curing Compound

TECHNICAL PROVISIONS

SECTION 03 - REINFORCING STEEL

TP-301 SCOPE:

Furnish all labor, materials, equipment, and incidentals as required and perform all operations in connection with the placement of reinforcing steel and wire fabric reinforcing, complete, in strict accordance with the applicable drawings and these specifications.

TP-302 MATERIAL:

Reinforcing bars shall meet the requirements of the Standard Specifications for Billet-Steel Bar (intermediate grade) for Concrete Reinforcement, ASTM A615. Welded wire mesh shall meet the requirements of the Standard Specifications for welded Steel Wire Fabric for Concrete Reinforcement, ASTM A185.

The use of cold twisted bars will not be permitted. Wire fabric shall be used only when specified and shall be the type shown on the drawings and approved by the Owner or Owner's Representative.

TP-303 METHOD OF CONSTRUCTION:

When placed, all reinforcement shall be free from dirt, oil, paint, grease, mill scale, loose or thick rust. When bending is required, it shall be accurately done without the use of heat, and bars having cracks or splits at the bends shall be rejected. All reinforcement shall be placed in the exact position shown on the drawings, and shall be securely held in position by wiring to, and blocking from, the forms, and by wiring together at intersections, such that it will not be displaced during depositing and compacting of concrete. Precast concrete blocks, plastic chairs or metal chairs shall be used for supports where applicable. Rock supports will not be allowed.

Placing and fastening of reinforcement in each section of the work shall be approved by the Owner or Owner's Representative before any concrete is deposited in the section. Cutting and bending, placement, handling and storage, and installation of reinforcement shall be in accordance with American Concrete Institution (ACI) standards.

TP-304 MEASUREMENT AND PAYMENT:

Reinforcing steel shall not be measured and paid separately. Rather they shall be included in the unit or lump sum bid prices of those items shown on the Bid Schedule that require the inclusion of reinforcing steel, even if not specifically mentioned within the measurement and payment sections of those particular pay items.

TECHNICAL PROVISIONS

SECTION 06 – GRAVITY SANITARY SEWERS

TP-601 SCOPE:

The work covered by this section consists of furnishing all plant, labor, equipment, materials and incidentals, in connection with the construction of gravity sewer mains and appurtenances, in accordance with these drawings and specifications.

TP-602 GENERAL:

All facilities shall be constructed in the locations to the grades and of the sizes shown on the drawings. Excavation, trenching and backfilling shall be in accordance with Section 01 of these Technical Provisions. Any section of sewer that is found defective in material, alignment, grade or joint shall be corrected so as to meet these specifications and drawings.

TP-603 MATERIALS:

A. Pipe, Joints and Fittings

1. PVC Gravity Sewer Pipe: Sewer pipe shall be PVC and shall conform to all requirements of product standard ASTM D3034 for pipe diameters up to 15 inches and ASTM F679 for 18-inch to 48-inch diameter sewer mains. Sewer pipe shall meet the pipe compound requirements of ASTM D1784 and shall be made with PVC 1120 resin, Type I, Grade I. Pipe stiffness shall meet ASTM D2412. Pipe shall be nominal size, SDR-35. Joints shall be furnished with one end belled. The joint shall be integral bell and spigot with a Rieber rubber gasket. The integral bell shall meet ASTM D 3212. The gaskets shall be as recommended by the pipe manufacturer and shall meet ASTM F477.

   Plastic pipe with scratches, gouges, or grooves deeper than 10 percent of the wall thickness shall be rejected.

2. Services Wyes and Risers: PVC fittings utilized shall be single gasketed bell and spigot push-on type, meeting ASTM 3034.

3. Ductile Iron Pipe: All ductile iron pipe shall be in accordance with AWWA C151 and shall be in 18 to 20 foot lengths with single rubber gasket (push-on) joints in accordance with AWWA C111. Pipe shall be 350 psi rated. All ductile iron pipe used for sewer shall be cement-mortar lined in accordance with ASTM A746 and AWWA C104.

B. Manholes

1. General: All concrete used in constructing the manhole shall conform to Section 02 of the specifications. All concrete used for manholes shall be batched with a chemical resistant admixture for protection against hydrogen sulfide gas. The admixture shall be equal to Moxie 1800 Super-Admix as manufactured by Moxie International. Reinforcing steel shall conform to Section 03 of these Technical Provisions. Steps shall be aluminum, equal to Alcoa No. 12653 A, or 1/2-inch Grade 60, steel reinforced copolymer polypropylene plastic, M. A. Industries or approved equal, not less than 10 inches in width. If the polypropylene steps are utilized, care shall be taken to install them exactly according to the manufacturer's recommendations.

2. Lines and Grades: All manhole locations shall be as shown on the drawings unless field changes are necessary. Sewer line cut stakes shall be provided by the Contractor at each manhole and at the midpoint between each manhole at a minimum. A minimum of 2 offset stakes shall be provided for each cut stake. Further information on staking is found in TP-1.

3. Manhole Frames and Covers: Frames and covers shall be made of cast iron with a combined weight (frames and cover) of not less than 266 pounds. Cast iron frames and covers shall conform to drawings in all essentials of design. The cover shall have a lifting pocket and shall not be vented. Manhole frames and covers shall meet ASTM A48. Before leaving the foundry, all castings shall be thoroughly cleaned after which they shall be dipped twice in a preparation of hot asphalt or coal tar and oil, in such a manner as to form a firm coating. The manhole and covers shall be set such that the top of the cover shall be 3 inches above unpaved roads where paving is expected later or ground level as shown on the drawings or as directed by the Owner or Owner's. Frames and covers shall be East Jordan Iron Works, Inc. Product No. 00202301, Catalog No. 2023A and 2023Z1, Reference Product No. 00202313 and 00202351, or approved equal.

4. Manhole Bases: Bottom manhole sections shall have integral precast base or floor slabs. Manhole bases shall be a minimum of 6 inches thick for 48 inch diameter manholes and a minimum of 8 inches thick for manholes larger than 48 inches. If precast concrete manhole bases are used, they shall be bedded on 8 inches of crushed rock or gravel meeting the following requirements: 100% passing a 40 mm screen and not more than 10% passing a No.40 sieve, with uniform grading. Precast bases with precast channels shall be pre-approved on a case-by-case basis by the Owner or Owner's representative. Cast in place base slabs shall be constructed with reinforced concrete as shown in the detail plans. The contractor shall submit detail drawings showing the size, placement, and spacing of reinforcing bars for manhole

bases. This requirement applies for both pre-cast and cast-in-place manhole bases. Cast in place base slabs shall be constructed with a keyed joint for the manhole barrels to be installed into as shown on the detail drawings.

5. Standard Manholes: Standard manholes are those which have a depth, measured from the invert of the outlet pipe to the top of the cover, greater than 6 feet. Standard manholes shall be constructed of 4 feet inside diameter, 5 inches thick precast concrete manhole sections. Cone sections shall be eccentric, 5 inches thick precast concrete. Standard manholes shall have a 6 inch thick concrete base slab, and shall be constructed as shown on the detail drawings.

6. Shallow Manholes: Shallow manholes shall have a depth of 6 feet or less, and shall be constructed of 4 feet inside diameter, 5 inches thick precast concrete sections with 8 inch thick reinforced concrete flat top cover and 6 inch thick base slabs. Shallow manholes shall be constructed as shown on the detail drawings.

7. Inlet Manholes: Inlet manholes shall have a depth of 6 feet or less, and shall be constructed of 4 feet inside diameter, 5 inches thick precast concrete sections with 6 inches reinforced concrete cover and base slabs. The inlet manhole shall be constructed as shown on the detail drawings.

8. Diversion Manholes: Diversion manholes shall have a depth of 6 feet or less, and shall be constructed of 4 feet inside diameter, 5 inches thick precast concrete sections with 6 inches reinforced concrete cover and base slabs. Diversion manholes shall be constructed as shown on the detail drawings. Each diversion manhole shall be provided with a fiberglass gate frame and gate. The fiberglass gate frame shall have a thickness of 3/16-inch. The gate frame shall have a channel that is ¼-inch. The fiberglass gate shall be ¼-inch thick. The gate frame and gate shall be constructed as shown on the detail drawings.

9. Waterstops: All pipe penetrations through the manhole shall be equipped with waterstop devices. Waterstop devices shall be equal to concrete manhole adapter as manufactured by Fernco. All penetrations shall then be grouted to provide a watertight penetration.

C. Terminal Sewer Main Cleanouts: Such cleanouts shall be of the same material as the gravity sewer main and sized as called for on the bid schedule. Cleanouts are to be constructed as shown on the detail drawings. Frame and lid shall be equal to East Jordan Iron Works, Inc. Product No. 00157804, Catalog No. 1578ZPT and 1578APT with a locking cover. Covers shall be marked "SEWER. The open pipe inside the locked cover shall be plugged with a Cherne Original Gripper, or equal.

D. Warning Tape: Warning tape shall be green in color with "Caution - Buried Sewer Line Below" continuously printed on it. Tape shall be a minimum of 3-inches wide, 5 mils total thickness, composed of plastic with a metal foil core, and equal to Traceline Underground Utility Marking Tape. The warning tape shall be installed above the pipe with an 18-inch maximum bury depth. This tape shall also be installed on sewer service lines.

E. Marker Post: 2-1/2 inch diameter aluminum or steel utility markers with stampable brass or aluminum caps shall be installed to mark the location of all manholes and terminal sewer main cleanouts. Marker posts shall be painted with a minimum of 2 coats of yellow paint designed for outdoor commercial use. The marker posts shall be properly cleaned and the surface prepared in accordance with the paint manufacturer's recommendations prior to painting. Markers shall be 60-inch long, 2.5 inch diameter, Bernsten Model A1NBF60-OS aluminum posts, or approved equal. Marker posts shall be installed, to leave 36 inches exposed above ground. Where possible, the markers shall be located immediately above the indicated item. The Owner will specify the location for markers requiring offset installation. The Contractor shall be responsible for accurately stamping the location, orientation and size of the sewer main, manholes, terminal cleanouts, and appurtenances on the cap. Installation and stamping of marker posts shall be considered incidental to installation of sewer main, manholes, terminal cleanouts, and appurtenances.

Under no circumstances shall marker posts be installed within the right-of-way of any roadways, unless specifically indicated on a right-of-way permit. Instead, the contractor shall install carsonite marker posts to mark the locations of valves, vaults, bends, tees, crosses, interconnections, etc. within the right-of-way of roadways. Carsonite markers shall be 72 inches in length, 3.75 inches in width, blue in color, model CRM306607 with anchor barb and "Caution Sewer Pipeline" text on the marker as manufactured by Carsonite Composites, or equal. The carsonite markers shall be installed directly over the item that it is marking with a 24 inch bury depth.

TP-604 TRENCH EXCAVATION AND BACKFILL:

Trenching and backfilling operations shall be performed as specified in Section 01 of the Technical Provisions.

TP-605 INSTALLATION OF GRAVITY SEWER LINES:

The bottom of the trench shall be shaped to give uniform support to the pipe. Pipe laying shall proceed upgrade, with the spigot end pointing in the direction of the flow. Each pipe shall be laid true to line and grade as shown on the drawings, and in such a manner as to form a close concentric joint with the adjoining pipe. As the work progresses, the interior of the sewer shall be cleared of all dirt and extraneous materials of every description. If the maximum width of the trench at the top of the pipe specified in Section 01 of these Technical Provisions is exceeded for any reason other than at the direction of the Owner or Owner's representative, the Contractor shall install such concrete

cradling, encasement, gravel base or other bedding as may be required to satisfactorily support the added load of the backfill. Trenches shall be kept free from water and the pipe shall not be laid when conditions of the trench or weather are unsuitable for such work. At all times when work is not in progress, all open ends of pipe and fittings shall be securely closed so that no trench water, earth or other substances will enter the pipe.

TP-606 WATER AND SEWER LINE SEPARATION REQUIREMENTS:

A. General: Water lines located near sewers present conditions for serious potential cross contaminations. Protection from cross contamination can be provided by separation of the facilities and use of special piping materials. For measuring separation between pipes, all measurements shall be the clearance between pipes (pipe O.D. to pipe O.D.).

For the purposes of this section, the term "lines" shall include mains, laterals, and service lines for both water and sewer.

B. Horizontal Separation of Water and Sewer Lines: When water and sewer lines are laid parallel to each other, the horizontal distance between the water and sewer lines shall be at least 10 feet. Each line shall be laid in a separate trench.

When physical conditions, such as an existing obstruction, will not allow the required 10 foot horizontal separation, the water and sewer lines may be laid closer than 10 feet if the bottom of the water line is at least 18 inches above the top of the sewer line.

C. Vertical Separation of Water and Sewer Lines: When water lines cross sewer lines, the water line should be above the sewer line with no less than 18 inches vertical clearance (Measuring pipe O.D. to pipe O.D.).

Whenever possible the water line shall be above the sewer line. If the minimum 18 inch clearance cannot be obtained with the water line above the sewer, the water line must be installed under the sewer line.

Where a water line must cross under a sewer line, a vertical clearance of at least 18 inches between the bottom of the sewer line and the top of the water line shall be maintained. The water main shall be the normal water distribution pipe as specified on the construction drawings, with a 20 foot pipe section centered on the sewer crossing. No joints in sewer lines shall be permitted within 9 feet of a water line.

Where a water line must cross sewer service lines or mains, and the water line is not a minimum of 18 inches above the sewer service line or main, special protection is required. In these instances, the sewer service line or main shall be reconstructed of ductile iron pipe of the same size as the original sewer service line or main for a distance of 10 feet on either side of the water/sewer crossing point. As an alternative method of providing special protection, the contractor may place concrete a

minimum of 8” greater than the outside diameter of the pipe (i.e. 4” of concrete all the way around the pipe) for a length of 20 feet (10 feet on either side of the water/sewer crossing point), if approved by the project engineer. Concrete shall meet TP-2 requirements. All existing sewer grades shall be maintained.

D. Water Main Separation from Sewer Manholes: No water pipe shall pass through, under, or come into contact with any part of a sewer manhole.

E. Separation Between Water Lines and Components of the Sewage Disposal System: Water lines shall not be installed within 10 feet of a septic tank, within 25 feet of a drainfield, or 50 feet from an outhouse. Also, waterlines shall not be installed within 100 feet of the perimeter fence of an individual lagoon, or within 500 feet of the perimeter fence of a community lagoon.

TP-607 CONCRETE ENCASEMENT OF SEWER MAIN:

Sewer line sections indicated on the plans as requiring concrete encasement shall be constructed in accordance with the detail drawings. Transition from PVC to DI sewer pipe shall be accomplished with approved a transition boot. DI piping shall extend a minimum of 6-1/2 feet beyond the limits of indicated concrete encasement unless otherwise directed in the plans and detail drawings. Concrete requirements shall be as indicated in Section 02 of these Technical Provisions.

TP-608 INSTALLATION OF MANHOLES:

Manhole invert channels shall be smooth and semi-circular in shape, conforming to the inside of the adjacent sewer pipe section. The invert shall be finished smoothly with a semi-circular cross section. Flat-bottomed inverts shall not be acceptable. Inverts with humps or low spots or roughness of finish which will catch solid materials will not be acceptable. Inverts shall not be brush finished. A minimum invert elevation drop of one-tenth of a foot from the entrance to the outlet shall be provided in all manholes where there is a change in direction, or change in grade. Changes in direction of flow shall be made with a smooth curve of as large a radius as the size of the manhole will permit. S-curves will not be acceptable. Changes in sizes and grade of the channels shall be made gradually and evenly. The manhole shall be positioned such that the pipes intersect in the center of the manhole circle. The invert channels will be formed directly in the concrete. For those manholes where the sewer pipe does not change grade or slope, the invert may be constructed by laying a full section of sewer pipe through the manhole and cutting out the top half after the surrounding concrete has hardened.

The floor of the manhole outside the channels shall be smooth and shall slope toward the channel at a 15 percent grade. Manholes shall be provided with aluminum or copolymer polypropylene steps, installed as shown on the drawings. Any deviation of alignment of more than 3 inches for any step shall be cause for it to be reinstalled at the Contractor's expense.

The tops of all manholes shall have a concrete collar of the dimensions shown on the drawings. Manholes shall be installed at the locations and elevations shown on the site plans or as directed by the Owner or Owner's representative in the field. Joints between precast manhole sections shall be sealed with "Ram Nek" bituminous rope type sealer or equal. The sections shall then be grouted to a smooth finish on the interior and exterior of the manhole. Grout for jointing shall be as specified in Section 02 of the Technical Provisions. Manhole sections, and adjustment rings if required, shall be grouted in place when the manhole is constructed. The grout shall be spread evenly over the entire mating surface. The maximum number of adjustment rings shall be as indicated on the plans. The jointing and sealing materials shall be approved by the Owner or Owner's representative prior to installation.

Any drop manholes shall be constructed at the locations shown on the plans in accordance with the details shown on the construction drawings. Bases, walls and cones shall conform to the drawings. The manhole covers shall be set to the elevations shown on the drawings.

All connections between sewer pipe and manhole walls shall be sealed with non-shrinking grout in such a manner to make the manholes water tight.

Manholes shall not be acceptable if any evidence of infiltration into them is found. The Contractor shall take whatever actions are necessary, at his expense, to ensure that the manholes are completely watertight.

Precast manholes shall not be altered or modified in anyway. Precast manhole bases, barrel sections, etc. shall be installed in their precast condition. Chipping or altering the concrete shall not be allowed.

TP-609 CONNECTION TO EXISTING MANHOLES:

Connection of newly constructed sewer mains to existing manholes shall be of either the drop or at-grade type as indicated in the drawings and listed on the bid schedule. Reconstruction of manhole bases and inverts, all necessary piping, and associated work required to complete the connection shall comply with the provisions of Section TP-608.

All pipe entrances into the existing manhole shall be core bored, and a waterstop and watertight sealer shall be installed on each pipe penetrating into the manhole. All voids shall be repaired with non-shrink grout. Grouted areas shall be painted with bituminous coating on exterior. The invert shall be constructed as specified in TP-608 Installation of Manholes. Chipping and altering existing concrete inverts to connect the new sewer main pipe into the manhole is allowed.

TP-610 TESTING:

A. Sewer Main Alignment: After the gravity sewer lines have been completely backfilled and the contractor has verified the line as ready for testing, the Owner or his/her representative will check the alignment by shining a light between manholes.

Any deviation from true line or grade may be cause for rejection of the line. Any deviation from true line or grade which prevents water from draining by gravity from the sewer system, including manholes, shall be corrected such that the facilities meet these specifications and drawings. For horizontal alignment only, a deviation allowance of one-quarter of the inside diameter of the pipe may be excepted by the Owner or Owner's representative.

B. Sewer Main Water Tightness:

Testing for water tightness in gravity sewer mains may be accomplished by either of the following two methods:

1. Exfiltration/Infiltration: Tests for water tightness in the gravity sewer mains shall be made by the Contractor in a manner approved by and in the presence of the Owner or Owner's representative. The sewer and manhole connections shall not leak under either external or internal water pressure in excess of 10 gallons per day per inch diameter per 1000 feet of sewer. The test shall be run for a minimum of a four hour period.

   Infiltration testing shall be completed under existing ground water conditions. Exfiltration testing shall be conducted under an internal pipeline test pressure generated by a manhole water level at least 1 foot above the highest elevation of the sewer main to be tested. Leakage by either infiltration or exfiltration greater than specified above shall be corrected by the Contractor at his expense. All equipment and water for these tests shall be furnished by the Contractor. This test will be made after the line has been completely backfilled.

2. Low Pressure Air Test:
   - Test Requirements & Setup:

     a. Test each newly installed section of gravity sewer line between manholes.
     b. Slowly introduce air pressure to approximately 5.0 psig.
     c. Allow pressure to stabilize for at least five (5) minutes. Adjust pressure to 5.0 psig or the increased test pressure as determined below if groundwater is present. Start the test.

   - Test Procedure:

     a. Determine the test duration for a sewer section with a single pipe size from the table below:

Low Pressure Air Test – Test Times	
Sewer Main Diameter (inches)	Test Time (Minutes/100 Feet of Sewer Main)
8	1.2
10	1.5
12	1.8
24	3.6

b. Record the drop in pressure during the test period. If the air pressure has dropped more than 1.0 psig during the test period, the line is presumed to have failed. If the 1.0 psig air pressure drop has not occurred during the test period, the test shall be discontinued and the line will be accepted.

c. If the line fails, determine the source of the air leakage, make corrections and retest. The Contractor has the option to test the section in incremental stages until the leaks are isolated. After the leaks are repaired, retest the entire section between manholes.

C. Flushing: The Contractor shall flush all sewer lines before pre-final inspection to remove sand, silt and other foreign material which might have entered the pipe during construction. Water used for flushing shall be domestic quality or as approved by the Owner or his/her representative. All equipment and water for the flushing shall be furnished by the Contractor. This test will be made after the line has been completely backfilled. The Contractor shall dispose of all water and foreign matter after flushing in an approved manner.

D. Deflection Test: The maximum allowable deflection (reduction in vertical inside diameter) for PVC pipe shall be five percent. However, up to seven and one half percent may be allowed 30 days after final backfilling. Deflection testing is required in all cases between all manholes. All locations with excessive deflection shall be excavated and repaired by re-bedding or replacement of the pipe. Acceptable methods of deflection testing include use of properly sized go-no-go mandrels or deflectometer. Deflection testing is not required for ductile iron sewer mains.

E. Manhole Testing: All manholes shall be tested for watertightness. Each manhole shall be tested immediately after assembly and prior to backfilling. All lift holes shall be plugged with an approved non-shrink grout. All pipes entering the manhole shall be plugged, taking care to securely brace the plug. If the manhole fails the initial test, necessary repairs shall be made and the manhole shall be retested. One of the following methods shall be used.

1. Vacuum Testing: Vacuum testing should be conducted in accordance with ASTM C-1244 (Vacuum Test for Concrete Manholes), except as modified below. The vacuum test head shall be placed inside the top section and the seal inflated in accordance with the manufacturers' recommendations. A

vacuum of 10 inches of mercury shall be drawn and the vacuum pump shut off. With the valves closed, the time shall be measured for the vacuum to drop to 9 inches. The manhole shall pass if the time is greater than 60 seconds for 48-inch diameter, 75 seconds for 60-inch, and 90 seconds for 72-inch diameter manholes.

2. Hydrostatic Testing: Hydrostatic testing shall be conducted in accordance with ASTM C-969 except as modified below. The mains into and out of the manhole shall be stoppered with a suitable device such as a tethered pneumatic plug. The manhole shall be filled with water to the ring. After a period of at least one hour to allow for concrete absorption and to allow the water level to stabilize, the manhole shall be refilled and the water level shall be checked. The hydrostatic test shall then begin and shall be administered for a period of 4 hours. If the water level is found to drop more than ¼ inch per foot of depth of the manhole over this 4 hour duration, then the leakage shall be considered excessive and the Contractor shall be required to make all necessary repairs and retest the manhole. The exterior of the manhole shall be inspected during this period for visible evidence of leakage. Visible moisture, sweating, or beads of water on the exterior of the manhole shall not be considered leakage, but any water running across the concrete surface will be considered leakage and shall be repaired to the satisfaction of the Engineer regardless of the volume of water lost during the test.

TP-611 CLEANUP:

Upon completion of the work, the entire site shall be cleared of all debris, and the ground surface shall be finished to smooth and uniform slopes. All fences, clotheslines, gravel driveways or other obstructions removed during construction shall be left in a condition at least equal to their condition prior to construction. Cleanup shall be considered an incidental item and no additional payment shall be made for it, but rather its costs shall be merged with the applicable pay item irregardless of whether cleanup is specifically included in the measurement and payment section.

TP-612 MEASUREMENT AND PAYMENT:

A. Gravity Sewer Main: Gravity sewer main shall be measured in linear linear feet along the centerline of the pipe, center to center of the manhole without deduction for fittings or diameter of manholes, for each of the various sizes and types of pipe installed. Payment for sewer pipe shall be at the contract unit price for the various sizes and types of sewer main installed as shown on the Bid Schedule. This price shall be full compensation for furnishing all labor, equipment, materials, exfiltration/infiltration testing, and incidentals required for a complete installation, including but not limited to excavation, bedding, stabilization material, laying and jointing pipe, exfiltration/infiltration testing or air testing, supplying water, plugging, measuring, flushing, backfilling, as-builts, and final cleanup.

B. Shallow Manholes: Shallow manholes shall have a depth of 6 feet or less when measured from the invert of the outlet pipe to the top of the cover, and shall be measured each. Payment shall be at the contract unit price shown on the Bid Schedule. This price shall be full compensation for furnishing all labor, equipment, materials, and incidentals required for a complete installation, including but not limited to excavation, concrete, frame and cover, steps, adjustment of height, invert forming, connection to sewer lines, backfilling, as-builts, and final cleanup.

C. Standard Manholes: Standard manholes shall have a depth greater than 6 feet when measured from the invert of the outlet pipe to the top of the cover, and shall be measured each. Payment shall be at the contract unit price for the various depths of manholes installed as shown on the Bid Schedule, which shall be full compensation for furnishing all labor, equipment, material, and incidentals required for a complete installation, including but not limited to excavation, concrete, frame and cover, steps, adjustment of height, invert forming, connection to sewer lines, backfilling, as-builts, and final cleanup.

D. Drop Manholes: Drop manholes shall be measured each. Payment shall be at the contract unit price shown on the Bid Schedule, which shall be full compensation for furnishing all labor, equipment, material, and incidentals required for a complete installation, including but not limited to excavation, concrete, frame and cover, steps, adjustment of height, invert forming, connection to sewer line, backfilling, as-builts, and final cleanup.

E. Inlet Manholes: Inlet manholes shall be measured each. Payment shall be at the contract unit price shown on the Bid Schedule, which shall be full compensation for furnishing all labor, equipment, material, and incidentals required for a complete installation, including but not limited to excavation, concrete, frame and cover, gate frame and gates, steps, adjustment of height, invert forming, piping, connection to sewer line, backfilling, as-builts, and final cleanup.

F. Diversion Manholes: Inlet manholes shall be measured each. Payment shall be at the contract unit price shown on the Bid Schedule, which shall be full compensation for furnishing all labor, equipment, material, and incidentals required for a complete installation, including but not limited to excavation, concrete, frame and cover, gate frame and gates, steps, adjustment of height, invert forming, connection to sewer line, backfilling, as-builts, and final cleanup.

G. Terminal Sewer Main Cleanouts: Sewer main cleanouts installed at the terminal end of a sewer main shall be measured each. Payment shall be at the contract unit price on the Bid Schedule, which shall be full compensation for furnishing all labor, equipment, material, and incidentals required for a complete installation, including but not limited to excavation, concrete, frame and cover, fittings, backfilling, as-builts, and final cleanup.

H. Connection to Existing Manhole: Connections to existing manholes shall be measured each. Payment shall be at the contract unit price shown in the Bid Schedule. This price shall be full compensation for furnishing all labor, equipment, material, and incidentals required for a complete installation, including but not limited to excavation, cutting into the existing manhole, grouting, fittings, removing the existing invert, pouring and forming a new invert, backfilling, as-builts, and final cleanup.

I. Water and Sewer Main Crossings - Sewer Mains: All costs associated with completion of water and sewer main crossings shall be merged with other bid items and will not be considered a separate item for payment. No additional payment will be made for installation of ductile iron pipe associated with water and sewer main crossings.

J. Concrete Encasement: The concrete encasement shall be measured in linear feet along centerline of the encased pipe, beginning to end of encasement. Payment shall be at the contract unit price shown in the Bid Schedule, which shall be full compensation for furnishing all labor, equipment, materials, and incidentals required for a complete installation.

TP-613 SUBMITTALS:

A. PVC sewer pipe and fittings
B. Ductile iron sewer pipe and fittings
C. Manhole ring and cover
D. Manhole steps
E. Pre-Cast Manhole including base and pre-cast channels
F. Sewer main warning tape
G. Cleanout frame and lid
H. Exfiltration/Infiltration/Air testing method
I. Fiberglass gate frame and gates
J. Detail drawing of size, placement, and spacing of reinforcing bars for manhole bases

TECHNICAL PROVISIONS

SECTION 40 - SEWAGE TREATMENT LAGOON CONSTRUCTION

TP-4001 SCOPE: The work within this section consists of furnishing all labor, equipment, materials, and incidentals in connection with the sewage lagoon improvements in strict accordance with the construction drawings, construction detail drawings, construction notes and these specifications.

TP-4002 GENERAL: The work consists of the installation of an HDPE lined lagoon system including all appurtenances as shown on the drawings.

TP-4003 MATERIALS:

A. Pipe, Joints, and Fittings:

1. PVC Piping for Appurtenant Structures: PVC pipe and joints shall conform to the requirements of AWWA C900 or C909, DR18, Class 235 (minimum), Standard for Polyvinyl Chloride (PVC) Pressure Pipe, with gaskets meeting ASTM F477 and joints in compliance with ASTM D3139 or as otherwise defined on the Bid Schedule.

2. Ductile Iron Pipe for Appurtenant Structures: All ductile iron pipe and fittings shown on the drawings shall be in accordance with AWWA C151 and shall be in 18 to 20 foot lengths with single rubber gasket (push-on) joints in accordance with AWWA C111. Pipe shall be 350 psi rated. All ductile iron pipe used for sewer shall be cement-mortar lined in accordance with ASTM A746 and AWWA C104.

3. Gate Valves and Boxes: Gate valves shall be of cast iron or ductile iron body construction, bronze mounted, solid wedge, resilient seal, with 2-inch square operating nut, 200 psi operating pressure or higher, counterclockwise opening, inside screw, non-rising stems with O-ring seals, and conform to AWWA Specification C509 or C515. All valves shall be equal to the Mueller A-2360 or American Flow Control Series 2500, appropriately sized and with the correct connectors for the type of pipe in use.

   All valve boxes shall be cast iron and of the sliding type, sized for use with the appropriate valve. All boxes shall extend from the body of the valve to the finished grade. Valve boxes shall be Tyler 6855, or equal. All valve boxes shall be provided with locking covers. Lids shall be marked "SEWER" for gate valves. Debris plugs equal to a standard mud plug as manufactured by In Fact Corporation shall be installed inside each gate valve. Debris plugs shall be a push-in/pull-out plug made in the USA of 1.2 or 1.7 pound density closed cell polyethylene material and shall be

flexible, non-cracking, and shall not absorb water. The debris plus shall conform to the interior sides of the gate valve box without the need for any tightening mechanism. The device shall come complete with a 200 pound test polypropylene handle.

One valve key shall operate all valves and the Contractor shall furnish one such key to the Owner.

All valves shall be set and jointed to the pipe in the manner as set forth in the AWWA Standards for the type of connecting ends furnished. Before installing the valve, care shall be taken to see that all foreign material and objects are removed from the interior of the valve. All valves shall be set in and tied to poured-in-place concrete support blocks. Valve installation shall be as shown on the standard detail.

Valves and valve boxes shall be set plumb and valve boxes shall be placed over the valve or valve operator in such a manner that the valve box does not transmit shock or stress to the valve. Backfill shall be placed around the valve box and the valve shall be opened and closed to see that all moving parts are in working order. The cast iron valve box cover shall be set flush with the finished grade.

After installing the gate valve box, the contractor shall compact the area around the gate valve prior to installing the concrete collar to ensure that there is no settlement. A 2 foot diameter by 4 inch thick reinforced concrete collar shall be poured around each valve box. Before the concrete has hardened, the Contractor shall neatly scribe in the concrete pad the size of the valve and orientation of the pipe with two arrows.

4. Lagoon Level Gauge: Lagoon level gauge shall be 2-1/2" width, and of sufficient length to measure the entire depth of the lagoon. Gauges shall be equal to a Watermark Style "C" stream gauge graduated to hundredths and marked at every foot and every tenth. The contractor shall fill a 12 inch diameter AWWA C-900, DR-18, PVC pipe with concrete and embed pipe 3 inches into concrete block footing at center as shown in construction drawings. The bottom 6 inches of the lagoon level gauge shall be removed and place on top of 4 ft x 4 ft x 6 inch epoxy coated concrete footing with reinforcement bars as shown in construction drawings. The epoxy coating shall be fast cure, high solids, high build, marine coating equal to Macropoxy 646 coating by Sherwin Williams. Epoxy coating shall be applied in 2 coats with a total dry film thickness of 5 to 10 mils. Surface preparation and epoxy application shall be done in accordance with manufacturer's recommendations. An additional layer of lagoon liner measuring 10 feet by 10 feet shall be installed under the level gauge. The lagoon level gauge shall be strapped to pressure treated 2x4 lumber and PVC pipe with ½" wide minimum stainless steel straps at every 2 ft.

B. Concrete: Concrete shall be as specified in Section 2.

C. Reinforcing Steel: Reinforcing steel shall be as specified in Section 3.

D. Road Aggregate Base Course: Aggregate base course material shall for access road, top of berm and other driving surface shall be installed as shown on the drawings. Road aggregate base course shall consist of clean, hard durable pit-run gravel that has been screened to the following gradation prior to compaction:

% Passing by Weight		
Sieve Size	Min.	Max.
3/4-inch	100	---
No. 4	30	65
No. 8	25	55
No. 200	3	12

The material passing the No. 4 Sieve and retained on the No. 200 Sieve shall be uniformly graded.

The plasticity index of the material passing the No. 40 Sieve shall not be greater than 6 as determined by ASTM D424 latest revision.

TP-4004 LAGOON EARTHWORK:

A. Soils Testing and Inspection: Soils for lagoon construction shall be compacted during construction and prior to compaction testing and the installation of the lagoon liner. Soil testing shall be performed for the lagoon construction in accordance with TP-1. Required soil compaction testing frequencies are listed below for the lagoon construction:

Soil Compaction Testing Frequencies for Lagoon Construction		
Location	**Testing Frequency**	**Required Compaction**
Lagoon Bottom (Floor)	4 tests per 8” lift per acre	95%
Lagoon Berm Foundation (Area under Berm)	2 test per 6” lift per 250 linear feet of berm foundation spaced equally in the width of the berm	95%
Lagoon Berm	2 test per 6” lift per 250 linear feet of berm spaced equally in the width of the berm	95%
Pipe and Piping Structures in Lagoon Berm	1 test per pipe or pipe structure every other lift	95%

B. Excavation:

1. Surface Excavation (Strip and Grub): The area within the limits shown on the drawings shall be cleared of all spoil material including stumps, logs, brush, vegetation, existing sludge layer (if applicable), existing piping and concrete structures, and other foreign material. In addition, the finished grade surface where the liner will be placed shall be free of cobbles and stones to meet the requirements of the liner manufacturer. No trees shall be removed without prior approval of the Engineer. Such clearing shall be accomplished by stripping the indicated area to a depth not exceeding six inches (6") except as noted below for removal of large stumps and roots. Such material, shall be considered unsuitable for berm construction and shall be hauled and disposed of in a state licensed landfill at the contractor's expense. Any existing sludge may be disposed of by an alternate method if indicated on the plans and approved by the Owner or Owner's representative.

   Stumps and roots larger than two inches in diameter in cuts and in berms three feet or less in depth shall be removed to a depth of eighteen inches (18") below subgrade. Outside of the slope limits and under berms more than three feet deep, all stumps, and brush shall be cut off approximately level with the surface. No trees will be removed without prior approval of the Engineer.

2. Construction Excavation: Excavation of material to be used in the construction of berms (all material except that designated under item 1 above) shall be performed at such locations as are indicated on the drawings and shall be to the lines, grades and elevations shown.

   During the process of excavation, the grade shall be maintained in such condition that it will be well drained at all times. When necessary, temporary drains and drainage ditches shall be installed to intercept or divert surface water which may affect the prosecution or condition of the work.

   The rough excavation shall be carried to such depth that sufficient material will be left above the designated grade to allow for compaction to this grade. Should the Contractor through negligence or other fault, excavate below the designated lines, he shall replace such excavation with approved material in an approved manner and condition, at his own expense.

   All soft or unstable material, and material which will not readily compact when rolled or tamped, shall be removed as directed by the Engineer, and replaced with suitable material. The top six inches of excavated areas comprising the structural grade shall be compacted to a density equal to 95% of maximum density as determined by the Modified Proctor Test, ASTM D1557 or latest revision.

C. Excess Material Hauled to Waste: All excavated material not utilized or unsuitable for berm construction, including all strip materials, grub materials, and sludge shall be wasted off site in an area designated by the Owner and Engineer. Refer to TP-1 regarding requirements for traffic control per the Manual on Uniformed Traffic Control Devices (MUTCD) to ensure that hauling is performed in a safe manner. These materials shall be evenly spread over the designated area to a height not exceeding five feet over the existing ground elevation and wheel compacted.

D. General Fill Methods: Prior to placement of fill in any section, if required, the foundation of such section shall be loosened thoroughly by scarifying, plowing, or harrowing to a depth of six inches, except for the lagoon bottom which shall be 8-inches (see F. below). After removal of roots or other debris turned up in the process of loosening, the entire surface of the area shall be compacted to 95% of maximum density as determined by the Modified Proctor Test, ASTM D1557 or latest revision. The finished grade surface where the liner will be placed shall be free of cobbles and stones to meet the requirements of the liner manufacturer.

Fill materials shall be mixed as required to break up and blend the materials to obtain a uniform soil composition with uniform moisture content. Mixing can be performed either before or after placement of the material in a manner subject to the approval of the Owner or Owner's Representative. When mixing of the fill material is satisfactory, the lift shall be compacted to 95% of maximum density as determined by the Modified Proctor Test, ASTM D1557 or latest revision. Backfill placed adjacent to structures shall be compacted to 95% of maximum density as determined by the Modified Proctor Test, ASTM D1557 or latest revision. Portions of the fill which are not accessible to the roller shall be placed in 6-inch layers and compacted to the required density by approved mechanical tampers.

E. Berms: The berms shall be constructed with approved excavated material obtained from the lagoon site and shall be placed in 6-inch thick layers and compacted to a density equal to 95% of the maximum dry density as determined by the Modified Proctor Test, ASTM D1557 or latest revision.

All berms shall be filled and compacted as specified above, to the lines, grades and elevations as shown on the plans or as directed by the Engineer, with all surfaces trimmed and fine graded so as to produce a neat, regular appearance.

Rolling of the berm areas shall be done with an approved power roller weighing not less than ten tons. Any irregularities or depressions that develop under rolling shall be corrected by loosening the material at these places and adding, removing or replacing material until the surface is smooth and uniform. Any portion of the area which is not accessible to a roller shall be compacted to the required density by approved mechanical tampers.

All soft or unstable material and material which will not readily compact when rolled or

tamped, shall be removed as directed by the Engineer, and replaced with suitable material. The top six inches of excavated areas comprising the final berm shall be compacted to a density equal to 95% of maximum density as determined by the Modified Proctor Test, ASTM D1557 or latest revision.

The top of the berms shall be sterilized and covered with geotextile and base coarse. The area shall then be sprayed with an approved soil sterilant, equal to Primatol 25E Herbicide, to prohibit vegetation growth and shall be applied at a rate that is in accordance with the manufacturer's recommendations. The treated ground surface shall be completely covered with one layer of GCI 381 geotextile or equal. Geotextile shall be 3.8 oz per square yard, 35 mil thick non-woven geotextile. Any geotextile joints shall overlap a minimum of 12 inches. After placement of the geotextile, the entire area shall be covered with a 3 inch uniform layer of base coarse.

F. Lagoon Bottom: The lagoon bottom shall be constructed to the finished grade as shown on the drawings. The bottom of the lagoon shall be checked for smoothness and accuracy with surveying instruments, and if any portion is found to vary more than two tenths (0.20) of a foot above or below the finished grade, such portions shall be scarified, reshaped and recompacted until the required accuracy is obtained.

The 8-inches immediately below the HDPE liner shall be scarified by discing or using rippers on a grader, dozer, or other approved equipment and compacted to a density equal to 95% of the maximum dry density as determined by the Modified Proctor Test, ASTM D1557 or latest revision. Compaction and rolling shall conform to all provisions as specified under "Berms." All soft and yielding material, and material which will not readily compact when rolled or tamped, shall be removed, and replaced with suitable material as directed by the Engineer.

TP-4005 SLUDGE REMOVAL, HAULING AND PLACEMENT: If shown on the drawings and on the bid schedule, sludge removal, hauling, and placement is required. The contractor shall remove existing dried sludge in lagoon cell bottom as shown on the construction drawings. The contractor shall satisfy himself/herself as to the actual quantity of sludge material for removal and placement. The contractor shall apply a maximum of 1 inch dry sludge layer at a rate of 8-12 tons/acre across the biosolids land application site as shown in construction drawings. Prior to placement of dry sludge material, the contractor shall coordinate with Tribe to establish the boundaries of the land application site. Refer to TP-1 regarding requirements for traffic control per the Manual on Uniformed Traffic Control Devices (MUTCD) to ensure that hauling is performed in a safe manner.

TP-4006 MOISTURE CONTROL: The materials in each layer of the fill shall contain the amount of moisture, within the limits specified below, necessary to obtain the desired compaction. The moisture content shall be as uniform as practicable throughout any one layer of selected materials. The upper limit of moisture content in selected materials shall be that which will permit hauling, placing, and proper compaction with the Contractor's equipment without excessive deformation of

any fill area. The lower limit of moisture content shall not be less than 95% of the optimum. Material that is too wet shall be spread and permitted to dry, assisted by discing or harrowing, if necessary, until the moisture content is reduced to an amount within the specified limits. When material is too dry, the Contractor shall be required to wet each layer of the fill and harrowing, or other approved methods, shall be required to work the moisture into the material until a uniform distribution or moisture is obtained. Water applied on a layer of fill shall be accurately controlled in an amount so that free water shall not appear on the surface during or subsequent to rolling. Should too much water be added to any fill so that the material is too wet to obtain the desired compaction, the rolling and all work on that section of the fill shall be delayed until the moisture content of the material is reduced to an amount within the specified limits.

If, in the opinion of the Engineer, the top or contact surfaces of a partial fill section become too dry to permit a suitable bond between these surfaces and the additional fill to be placed therein, the Contractor shall loosen the dried materials by scarifying or discing to such depths as may be directed by the Engineer and shall dampen the loosened material to an acceptable moisture content, and shall compact this layer in accordance with the applicable requirements.

TP-4007 PIPING STRUCTURES:

A. Lagoon Transfer Structures (Three Valve Type): The lagoon inter-connecting structures shall be constructed at the locations shown in the plans and in accordance with the detail drawings. Piping shall be as shown on the detail drawing and shall meet TP-4003 requirements. Materials and construction including inlet/outlet collars shall be as indicated in TP-1, TP-2, TP-3, TP-4003, and the plans and detail drawings. The contractor shall install 2" brass or aluminum caps into the concrete collars for each valve in the transfer structure. The 2" brass or aluminum caps shall be engraved with the following information:

Valve Description	Information to Engrave on Brass/Aluminum Cap
Drain	___" Gate Valve. Normally Closed - Drain.
Mid-Level Draw	___" Gate Valve. Normally Closed – Mid-Level Draw.
High Level	___" Gate Valve. Normally Open – High Level.

B. Discharge Manhole (Force Main Discharge Into Lagoons): Discharge manholes shall have a depth as indicated in the construction drawing details. Discharge manholes shall be 4 feet inside diameter and 5 inches thick precast concrete sections with a 6 inch thick reinforced concrete cover. Manholes shall meet TP-2 requirements for concrete. The manhole shall be equipped with an 8-inch thick reinforced concrete flat top cover with a grated aluminum cover cast into the cover. The grated aluminum cover shall be 30 inches wide by 30 inches long and shall be equipped with an aluminum angle frame with ¼" diameter by 3 inch long anchors, and automatic hold-open arm and cover release, a spring assisted grated aluminum door, and shall be capable of opening to a 90 degree angle as manufactured by Ohio Gratings, Inc. or equal. Discharge manholes shall be constructed as shown on the detail drawings.

Discharge manhole option #1 (see detail drawings) shall be equipped with a high performance flexible pipe-to-manhole connector ("pipe boot") on pipe penetrations equal to a PSX Direct Drive as manufactured by Press-Seal Gasket Corporation. The pipe boot shall be installed per the manufacturer's recommendations. The pipe boot shall be installed in the concrete manhole wall at the same angle as the PVC discharge pipe. This shall be accomplished using foam hole-formers.

Exposed pipe from the discharge manhole into the lagoon shall meet TP-4003 requirements. Exposed PVC pipe shall be coated with 2 coats of paint. Paint shall be equal to Krylon Fusion brand spray paint for plastic. Paint color is subject to the approval of the Owner or Owner's Representative.

Discharge manholes shall meet TP-6 requirements.

C. Lagoon Inlet Structure (Above Water Surface Level – Gravity Sewer Main): Lagoon inlet structures that discharge above the water surface level of the lagoon cell shall be constructed as shown on the detail drawings. The pipe shall be supported by concrete filled 12" diameter C900 PVC pipe embedded into 3'x3'x8" thick reinforced concrete pads installed on top of an additional 10'x10' square section of 60 mil thick HDPE liner. Concrete support pads shall meet TP-2 requirements and shall be spaced such that each pipe bell is supported. The pipe shall be attached to the concrete pad using a ½" thick stainless steel cable or strap attached to the concrete with ½" diameter by 2" long stainless steel concrete drop in anchor and ½" diameter stainless steel bolts. A 4'x4'x6" thick reinforced concrete splash pad shall be installed underneath the pipe termination point as shown on the drawings. All submerged concrete shall be coating with epoxy coating. The epoxy coating shall be fast cure, high solids, high build, marine coating equal to Macropoxy 646 coating by Sherwin Williams. Epoxy coating shall be applied in 2 coats with a total dry film thickness of 5 to 10 mils. Surface preparation and epoxy application shall be done in accordance with manufacturer's recommendations.

D. Lagoon Inlet Structure (Bottom of Lagoon Cell – Gravity Sewer Main): Lagoon inlet structures that discharge at the bottom of the lagoon cell shall be constructed as shown on the detail drawings. The pipe shall be supported by 2'x2'x4" thick reinforced concrete pads installed on top of an additional 4'x4' square section of 60 mil thick HDPE liner. Concrete support pads shall meet TP-2 requirements and shall be spaced such that each pipe bell is supported. The pipe shall be attached to the concrete pad using a ½" thick stainless steel cable or strap attached to the concrete with ½" diameter by 2" long stainless steel concrete drop in anchor and ½" diameter stainless steel bolts. A 4'x4'x4" thick reinforced concrete splash pad shall be installed underneath the pipe termination point as shown on the drawings. All submerged concrete shall be coating with epoxy coating. The epoxy coating shall be fast cure, high solids, high build, marine coating equal to Macropoxy 646 coating by Sherwin Williams. Epoxy coating shall be applied in 2 coats with a total dry film thickness of 5 to 10 mils. Surface preparation and epoxy application shall be done in accordance with manufacturer's recommendations.

TP-4008 HDPE MEMBRANE LINER:

A High Density Polyethylene (HDPE) liner shall be installed on the floor and the side slopes of the newly constructed lagoon cell(s) as shown in the drawings; a textured HDPE liner shall be installed on the side slopes of the cells and on the cell floors.

A. High Density Polyethylene Material: High Density Polyethylene (HDPE) lining shall consist of 60 mil HDPE sheeting, Permalon PLY-X210 or equal. Polyethylene shall have a minimum density of 0.94 g/cm^3 (ASTM D 1505, a minimum yield strength of 2200 psi (ASTM D 638), and a carbon black content of 2%-3%. The materials supplied under these specifications shall be first quality products manufactured specifically for the purposes of this work and have been satisfactorily demonstrated by prior use to be suitable and durable for use in lining hydraulic structures. The liner must have good surface quality and be free of pinholes, striations, roughness, and blisters. Manufacturer's certification that all material standards are met shall be provided to the Engineer.

B. Field Installation: Field installation shall be performed by a factory authorized installation contractor. A representative of the liner manufacturer shall be in attendance during all phases of liner installation. The surface (substrate) to receive the liner shall be smooth and free of sharp objects that could puncture the lining. All vegetation and organic material shall be removed. The liner shall be installed over the prepared surfaces in accordance with factory recommendations for minimum handling and using methods that will not crimp, bend, or otherwise damage the material. Excessive wrinkles are to be removed prior to seaming. Horizontal field seams on slopes shall not be allowed.

   The liner shall be sealed to all structures and intruding pipes in accordance with the manufacturers recommendations and the detail drawings. Any portion of the liner damaged during installation shall be removed or repaired as recommended by the on-site factory representative. The liner shall be installed in a relaxed condition and shall be free of stress or tension upon completion of the installation. Stretching of the liner shall not be allowed.

   All joints, on completion of the work shall be tightly bonded. Any lining surface showing injury due to scuffing, penetration by foreign objects, distress from rough subgrade, or any seams not passing the required tests shall be replaced or covered and sealed with an additional layer of the same material of a proper size. All liners shall be terminated in an anchor trench as shown in the plans and detail drawings and in accordance with the manufacturer's recommendations. Gas vents shall be constructed in accordance with the detail drawings at locations and intervals as recommended by the liner manufacturer.

C. Material Seaming: Wherever possible, field seams shall be made by using a heat fusion (wedge) method as recommended by the liner manufacturer. Wedge welded seams shall consist of a double seam with an air channel between the seams. Extrusion welding will be allowed only for detail work, repairs, and in other areas where wedge welding cannot be

used. The contact surfaces of the panels shall be wiped clean to remove all dirt, dust or other foreign substances. The manufacturer's recommendations for field seams shall be strictly adhered to.

Test seams shall be made for each seaming machine each day prior to seaming any permanent liner materials, any time the seaming machine is turned off for more than 15 minutes, or if a substantial change in weather conditions occurs. A minimum of two shear and two peel tests are to be conducted on each test seam by using a field tensiometer furnished by the installer. Test seams must meet the manufacturer's requirements and all results recorded. No seaming shall be done until a successful test seam has been completed and recorded. Test records, along with manufactures minimums, shall be made available to the Engineer upon request.

1. Testing: The Contractor shall test all completed seams prior to acceptance. Pressurizing the air channel to a stabilized pressure of 30 psi shall test wedge seams. After a minimum of five minutes, a final pressure reading shall be taken. The maximum allowable pressure drop is 4 psi. All extrusion welds shall be tested visually by use of a soap solution and a vacuum box. In areas where this method is not possible (e.g. on pipe boots), the contractor shall perform a spark test to ensure that the extrusion weld is watertight. All test results are to be recorded and made available to the Engineer.

2. Safety Rope: The Contractor shall install a safety rope in every corner of the finished HDPE lined lagoon cell. The rope shall be multifilament twisted polyester rope or equal. The rope shall be 5/8- inch minimum diameter and shall have knots located every two feet. The Contractor shall attach the rope to a 1/2" stainless steel lag ring bolt placed in the center of a 12" x 12" x 24" thick concrete block buried flush with grade at the top of the berm. The rope shall extend from the top of the berm to the floor of the cell after the knots have been tied.

D. Warranty: Upon acceptance of the project, the Contractor shall provide a liner system warranty which shall cover all appropriate items that would cause the pond to leak greater than 500 gal./acre/day. Examples of such items would be rock penetration, abrasion, settlement, seaming, construction technique, ice, etc. This warranty shall be of sufficient dollar value to cover labor and materials to fully repair the liner and remedy the problem. This shall include, but not be limited to, detection of the leak, removal and replacement of liner and subgrade preparation. The minimum time period for a prorated warranty shall be twenty (20) years for materials and one (1) year for workmanship (such as field-seaming).

TP-4009 GEOCOMPOSITE GAS VENTING LAYER (GGVL)

Where shown on the drawings and indicated on the bid schedule, the contractor shall install a GEOCOMPOSITE GAS VENTING LAYER (GGVL) to aid in the venting of gases under the liner.

The GGVL shall be installed, including all necessary and incidental items, in accordance with the construction drawings and these specifications to provide a complete gas venting system for the liner.

A. MATERIALS:

1. The geonet of the GGVL shall be a tri-planar structure manufactured by extruding three sets of high density polyethylene strands to form a three dimensional structure to provide planar liquid flow. The geonet shall meet the property requirements listed in Table 1.

2. The geotextile of the GGVL shall be UV resistant, needle punched, and nonwoven polypropylene geotextile. The geotextile shall meet the property requirements listed in Table 1.

3. GGVL shall be Tenflow AirMax 350 mil composite manufactured by GSE Environmental Company (1800-435-2008), or engineer approved equivalent.

4. Labels on each roll of GGVL shall identify the length, width, lot and roll numbers, and name of Manufacturer.

TABLE 1: REQUIRED GGVL PROPERTIES

PROPERTY	TEST METHODS	UNITS	VALUE	QUALIFIER	FREQUENCY
TRI-PLANAR GEONET[1]					
Thickness	ASTM D 5199	mil (mm)	350 (8.9)	MAV	50,000 sf
Density	ASTM D 792	g/cm^3	0.94–0.96	Range	50,000 sf
Melt Flow Index	ASTM D 1238	g/10 min	1.0	MAX	50,000 sf
Carbon Black	ASTM D 4218	%	2-3	Range	50,000 sf
Thickness Retained From 10,000 hour creep test under 2,000 psf, and 20°C temperature	GRI-GC8	%	92	-	-
Creep Reduction Factor From 10,000 hour creep test under 2,000 psf, and 20°C temperature	GRI-GC8	-	1.05	-	-
GEOTEXTILE[1]					
U.V. Resistance (500 hrs)	ASTM D 4355	%	70	MARV	Per formula
Grab Tensile	ASTM D 4632	lbs (N)	160 (710)	MARV	100,000 sf
Grab Elongation	ASTM D 4632	%	50	MARV	100,000 sf
Tear Strength	ASTM D 4533	lbs (N)	65 (290)	MARV	100,000 sf
CBR Puncture	ASTM D 6241	lbs (N)	435 (1,936)	MARV	100,000 sf
AOS	ASTM D 4751	US Std Sieve(mm)	70(0.212)	MaxARV	540,000 sf
Permittivity	ASTM D 4491	sec^{-1}	1.4	MARV	540,000 sf
Water Flow Rate	ASTM D 4491	gpm/ft^2 ($l/min/m^2$)	110 (4481)	MARV	540,000 sf
GGVL					
Ply Adhesion	ASTM D 7005	lb/in (g/cm)	0.5 (89)	MARV	
Roll Sizes	12.5 ft x 200 ft (3.81 m x 61 m)				
Transmissivity[2] – MD					
Plate/Ottawa Sand/ GGVL/Geomembrane/ Plate, Gradient = 3.0 @ 1,000 psf 24 hour seating period	ASTM D 4716	m^2/sec	$7.0*10^{-4}$	MAV	540,000 sf

B. CONSTRUCTION:

1. Handling and Placement

a. After the subgrade has been constructed, tested, and approved by the Engineer, the surface shall be clean and free of excess dirt and debris.

b. The Contractor and the Installer shall handle all GGVL in such a manner as to ensure it is not damaged in any way. Precautions shall also been taken to prevent damage to underlying layers during placement of the GGVL.

The predominant flow direction of the GGVL is in the machine direction (roll direction), and thus should be installed in the intended direction of flow. This is generally achieved by deploying the product directly down the slope unless an alternative drainage path is specified by the Engineer.

c. If the project contains long, steep slopes, special care shall be taken so that only full-length rolls are used at the top of the slope

d. In the presence of wind, all GGVL shall be weighted with sandbags or the equivalent. Such sandbags shall be installed during placement and shall remain until replaced with cover material.

e. If necessary, the GGVL shall be positioned by hand after being unrolled to minimize wrinkles.

f. If the project includes an anchor trench at the top of the slope, the GGVL shall be properly anchored to resist sliding. Anchor trench compacting equipment shall not come into direct contact with the GGVL.

g. If there are any obstructions (such as outlet pipes or monitoring wells) while deploying the GGVL, the GGVL shall be cut to fit around the obstruction. Care shall be taken as to make sure there is no gap between the obstruction and the GGVL. The GGVL shall be cut in a way that the lower geotextile and geonet core is in contact with the obstruction and the upper geotextile has an excess overhang. There must be enough of the upper geotextile to be able to tuck the upper geotextile back under the GGVL to protect the exposed geonet core, and prevent soil particles from migrating into the geonet core flow channels.

2. Seams and Overlaps

Each component of the GGVL (geotextile(s) and geonet) shall be secured or seamed to the like component at overlaps.

a. Geonet Component

- Adjacent edges of geonet along the length of the GGVL, shall be overlapped 3 inches, see Figure 1(a), or if approved by the Engineer based on the site specific conditions, placed with the edges of each geonet butted against each other, see Figure 1(b). These overlaps shall be joined by tying the geonet cores together with white or yellow cable ties or plastic fasteners (minimum tensile strength of 50 lbs). These ties shall be spaced at a maximum of every 5 feet along the roll length, or a maximum of 2 feet if

the GGVL is installed vertically.

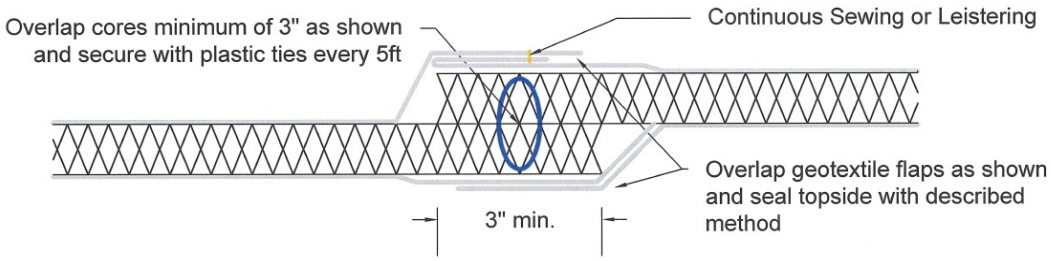

Figure 1(a). Overlap along roll length (side to side)

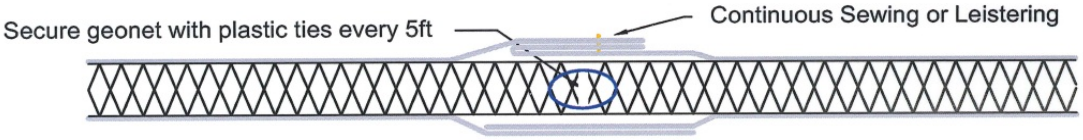

Figure 1(b). Butted along roll length (side to side)

- Adjoining GGVL rolls (end to end) along the roll width shall be shingled down in the direction of the slope, with the geonet portion of the top GGVL overlapping the geonet portion of the bottom GGVL a minimum of 8 inches across the roll width, see Figure 2. Geonet shall be tied every 12 inches across the roll width and every 6 inches in the anchor trench or as specified by the Engineer.

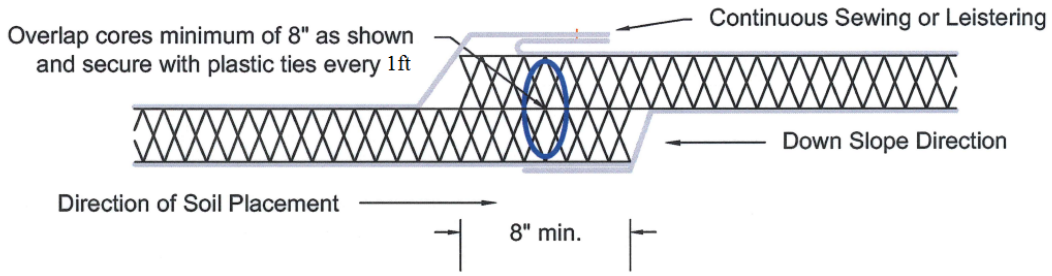

Figure2. Overlap along roll width (end to end)

b. Geotextile Component

- The bottom layer of geotextile (if any) shall be overlapped.

- The top layers of geotextile shall be sewn together, or at the discretion of the Engineer may be heat bonded or wedge welded. Geotextiles shall be overlapped a minimum of 4 inches prior to seaming or heat bonding. The seam shall be a two-thread, double-lock

stitch, or a double row of single-thread, chain stitch. If heat bonding is to be used, care must be taken to avoid burn through of the geotextile. It is important that the geotextiles be joined continuously along to the roll as to prevent any fugitive particle migration into the geonet core flow channels.

c. Slope Corner

In the slope corners, the direction of the slope changes at the corner diagonal line as illustrated in Figure 3. It's recommended to first place an additional panel along the corner diagonal line of the adjacent slope. The panels from the opposite slope should be placed to extend on top of the additional panel. Then the panel for the slope which contains the additional panel should be placed to meet (butted) the opposite slope panels.

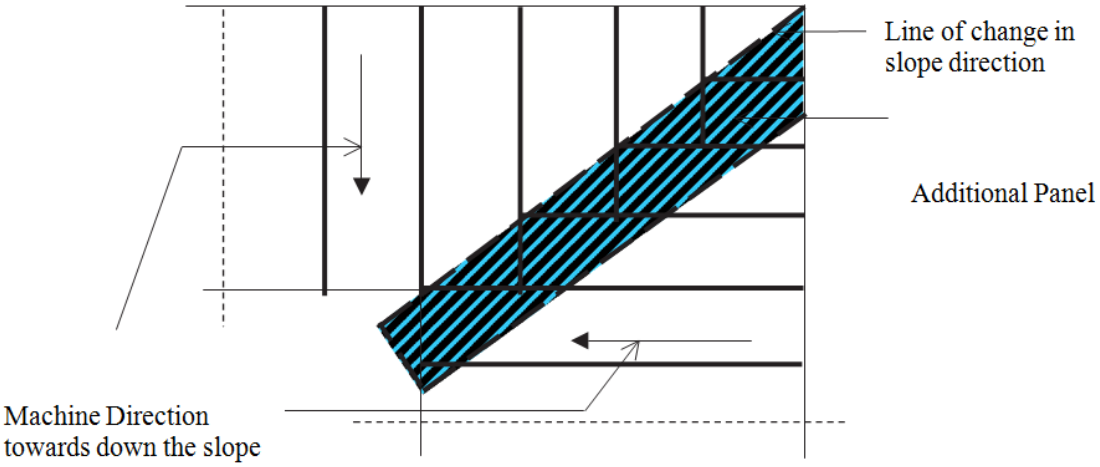

Figure 3. Detail of Slope Corners

3. Repairs

- Geotextile Damage

  Any small holes or tears in the top geotextile shall be patched with an 8" x 8" geotextile piece. The patching geotextile shall be the same as the original one. Apply the spray adhesive (*3M Super Hi-Strength 90 adhesive is the recommended)* to one side of the 8" x 8"geotextile patch. Center and apply the 8" x 8" geotextile patch over the blemish, hole, tear or thin spot in the geotextile. Firmly press 8" x 8" textile patch over the repair area. If the damaged area of the geotextile is greater than this standard patch size, a bigger size patch is recommended using a multitude of 8" x 8" patches. If the geotextile is damaged beyond 50 percent of the width of the roll, a continuous piece of fabric the same width as the GGVL may be cap-stripped directly to the adjacent seams by sewing a portion of the new geotextile in place.

- Geonet Damage:
  Any large rips, tears or damage areas on the deployed GGVL core shall be removed and patched by placing a patch extending 12" beyond the edges of the damaged areas. The patch shall be secured to the original geonet tying every 6 inches with approved tying devices. If the hole or tear width across the roll is more than 50% percent the width of the roll, the damaged area shall be cut out.

C. FAILING GGVL Construction Quality Assurance (CQA) TESTS:

In case of any failing CQA tests, "blocking" test on before and after the failing roll(s) shall be conducted to identify the affected rolls in the lot. The rejected rolls shall be excluded from the lot in consideration. The product manufacturer shall be responsible for any cost associated with blocking testing.

TP-4010 CLEANUP: Upon completion of the work, the entire site shall be cleared of all debris, and the ground surface shall be graded and finished smooth, uniform slopes and shall present a neat and workmanlike appearance. Cleanup shall be considered an incidental item and no additional payment shall be made for it, but rather its costs shall be merged with the applicable pay item.

TP-4011 AS-BUILT DRAWINGS: The Contractor shall be responsible for keeping accurate records of all installed items under this section of the specifications and indicating revisions of the government furnished construction drawings in sufficient detail to be accepted by the Engineer for as-built drawings. For the Contractor's information, sufficient detail under this contract means that the Contractor shall take accurate measurements and record them on the drawings to provide the minimum information of at least two swing ties and distances to permanent objects and/or marker posts for the location of any stabilization material placed; the location and depth of rock encountered; the location of any berm center line corners; all centerline distances; berm and bottom elevations at all corners and centers; and control structure elevations. Also to be noted on the plans is the final elevation of all manhole lids, inverts, and the ground immediately adjacent to the manhole lid and the distance and angles between the manholes. Further information on as-builts is contained in the Special Provisions section of these specifications.

The recording of the as-built information is considered an integral part of the progress of this construction and shall be reviewed with the Engineer in determining progress under this contract.

TP-4012 MEASUREMENT AND PAYMENT:

A. Lagoon Construction: The payment for the lagoon construction as specified herein shall be made at the per job price as listed in the bid schedule. The price will be full compensation for furnishing all labor, tools, equipment, and materials required to complete all excavation, construction, hauling excess material to waste, watering and compaction of the berms and excavated areas, bottom grade preparation of the lagoon, shaping and constructing the

berms, removal of existing sludge and wasting back into the percolation cell area, soils testing, safety rope, and all incidental work necessary to complete the work as shown on the drawings and as herein specified.

The estimated amounts of compacted fill and cut material in cubic yards are indicated on the drawings. They are meant only for estimating purposes and the Contractor shall satisfy himself as to the actual quantity of material required. The lagoon berm as shown on the plans shall be constructed at the lump sum price bid regardless of the actual quantity of materials hauled and compacted. Compensation for all incidentals not specifically listed in the bid schedule but specified under TP-40 shall be included in the lump sum price bid for Lagoon Construction.

The lump sum bid price for the lagoon construction shall also include payment for full compensation for furnishing all labor, equipment, materials, and incidentals required for complete installation of lagoon level gauge, epoxy coated concrete footing, stainless steel straps, wood and materials to complete all the work shown on the drawings and as herein specified.

B. Sludge Removal, Hauling and Placement: Payment for sludge removal, hauling and placement shall be made at the per job price as listed in the bid schedule for furnishing all labor, equipment, materials, and incidentals required for completion of all work as shown on the drawings and as herein specified. The estimated sludge removal quantity indicated on the construction drawings are based on hand calculations. They are meant only for estimating purposes and the contractor shall also satisfy himself/herself on the actual quantity of sludge material to be removed and placed at land application site within the reservation.

C. Lagoon Transfer Structures: Payment for construction of each transfer structure shall be at the unit price indicated on the bid schedule. Such payment shall be full compensation for furnishing all labor, equipment, material, and incidentals required for a complete installation, including, but not limited to excavation, form work, concrete, reinforcing steel, piping, liner penetrations, valves, valve boxes, insulation, vents, as-builts, and clean-up required to provide a complete and operational structure as indicated in the plans and detail drawings.

D. Lagoon Inlet Structures: Payment for construction of each lagoon inlet structure shall be at the unit price indicated on the bid schedule. Such payment shall be full compensation for furnishing all labor, equipment, material, and incidentals required for a complete installation, including, but not limited to excavation, form work, concrete, reinforcing steel, piping, liner penetrations, concrete pipe supports, stainless steel straps and connections, splash pads, additional HDPE liner layer under concrete, as-builts, and clean-up required to provide a complete and operational structure as indicated in the plans and detail drawings.

E. Discharge Manhole: Discharge manholes shall be measured each. Payment shall be at the

contract unit price shown on the Bid Schedule, which shall be full compensation for furnishing all labor, equipment, material, and incidentals required for a complete installation, including but not limited to excavation, concrete, frame and cover, hatch, adjustment of height, invert forming, pipe boots, connection to force main, connection of discharge pipe to lined lagoon, backfilling, as-builts, and final cleanup.

F. HDPE Liner: Payment for the constructed HDPE liner shall be at the contract unit price per acre shown on the Bid Schedule for furnishing all labor, equipment materials and incidentals for fabrication and installation of the lagoon cell liners specified. Such payment shall include, but not be limited to, furnishing materials, surface preparation, field fabrication and placement of liner, sealing and attachment to appurtenant pipes and structures, testing, and final trench anchoring.

G. Geocomposite Gas Venting Layer (GGVL): All work required for GGVL shall be at the contract lump sum price shown on the Bid Schedule for furnishing all labor, equipment materials and incidentals for fabrication and installation of the GGVL. Such payment shall include, but not be limited to, furnishing materials, surface preparation, field fabrication and placement of GGVL, sealing, testing, and final trench anchoring.

TP-4012 SUBMITTALS:

A. Soils testing laboratory
B. Piping materials
C. Lagoon level gauge structure and materials (gauge, epoxy, pipe, concrete, straps)
D. Piping Structure Materials
E. Equipment to be used for earthwork
F. HDPE liner and pipe boots
G. HPDE liner manufacturer's representative
H. Geocomposite gas venting layer (GGVL):
    1. Accreditations Certificates shall be submitted showing the GGVL manufacture's quality control laboratory is currently and have maintained a minimum of 2 consecutive year's accreditation via the Geosynthetics Accreditation Institute's laboratory accreditation program (GAI-LAP).
    2. Quality Control Certificates: For GGVL delivered to the site, quality control certificates shall be provided for every roll of GGVL. Each certification shall have the roll identification number(s), test methods, frequency, and test results.
    3. Shipping, Handling, and Storage Instructions: The Manufacturer's plan for shipping, handling, and storage shall be submitted for review.
    4. GGVL Panel Layout: The predominant flow direction of the GGVL is in the machine (roll) direction. The GGVL shall be installed to maximize its flow capability. The Contractor shall submit and have approved by the engineer a GGVL panel layout prior to placement of the GGVL.
    5. Furnish copies of delivery tickets or other approved receipts as evidence for GGVL received.

SECTION 11375

FLOATING AERATORS

PART 1 GENERAL

1.01 WORK INCLUDED

A. Floating aerators and appurtenant controls

1.02 RELATED WORK

A. Electrical (by others)

1.03 SUBMITTALS

A. Product and Performance Data

B. Operation and Maintenance Manuals
   1. In addition, the manual shall contain complete detailed instructions on the balancing procedure to be used for re balancing the propeller after it has been in service for an extended period of time. These instructions shall include, but not be limited to, a general procedural description, a detailed explanation of preparing the unit for balancing, for setting up the dynamic balanced portable balancing technique, a detailed description of the vector chart method of single plane balancing and sample balancing record forms.

C. All welding is to be performed by welders certified by the A.W.S. in accordance with the requirements set forth in the A.W.S. D1.1 Structural Welding Code. Certification of both the A.W.S. and employment by the manufacturer must be provided with submittals.

D. All product and welding certifications as specified in this Section (1.03)

1.04 PROJECT SITE CONDITIONS

A. As shown in the Schedule, Section 3.03.

1.05 QUALITY ASSURANCE

A. Aerators to be specifically recommended for the designed application by the manufacturer.

B. Aerators of other manufacturers which meet or surpass the materials and features of construction, and the performance of the selected aerators are acceptable. The ENGINEER shall be the sole judge as to equivalency.

C. Aerators and all their controls shall be supplied as a unit from a single manufacturer.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Aqua Aerobics Systems, Inc.

2.02 DESIGN CHARACTERISTICS

A. Drive Motor
1. Power as shown on schedule, Section 3.03.
2. Motor shall be wired for 460 volts, 60 cycle, three phase service.
3. Totally enclosed, fan cooled, and rated for severe chemical duty and 1.15 service factor.
4. Motor windings: nonhygroscopic with insulation equal to NEMA Class F.
5. Condensate drain located at the lowest point in the lower end bell housing.
6. A labyrinth seal shall be provided below the bottom bearing to prevent moisture from penetrating around the motor shaft.
7. All motor frame parting surfaces shall be deep registered and permatex-sealed.
8. All through bolts, nuts. and screws: Type 18 8 stainless steel.
9. Stainless steel nameplate: Provided with each motor, securely fastened thereto. Voltage, speed, insulation class, amperage, service factor, serial number and manufacturer's name shall be steel stamped in nameplate.
10. Where indicated in the schedule in Section 3.03, furnish aerators with two speed, two winding variable torque motors. Single wound, two speed motors shall not be acceptable.
11. High Efficiency Motor will be provided.

B. Motor Shaft
1. One piece continuous from the top motor bearing through the lower bearing and down to and through the propeller. This shaft will have a minimum diameter of 1-3/4".

2. Manufactured from 17 4 PH stainless steel, or comparable stainless steel having a minimum yield strength of 100,000 psi on units 3 HP and larger.
3. For one piece shaft arrangements, the following conditions are required:
    a. Motor support deflector shall utilize a shaft deflector limitor to limit the radial deflection of the motor shaft.
    b. Shaft deflector limitor: Located in the lower portion of the motor support deflector.
    c. Deflector limiter: Molded from Delrin and larger through the bore than the diameter of the motor shaft.

C. Aerators shall operate at no more than 1,200 rpm for motors between 20 HP and 75HP and below 1,800 rpm for motors between 3 HP and 15 HP.

D. Motor Bearing
1. Regreasable. Sealed bearings not acceptable. Top bearing shall be shielded on the bottom side only. Bottom bearing shall be open.
2. Two bearing configuration: Top and bottom bearing shall be of the combined radial and axial thrust type and shall be packed at the factory with Chevron SR1 2 or equivalent grease. Lower motor bearing inner race shall be locked to the motor shaft via a special washer and locking nut arrangement. Snap ring type bearing retainers not acceptable.

E. Diffuser Head
1. Designed to produce a liquid discharge in an angle of 90^{o} to the motor shaft and over a 360^{o} pattern in the horizontal plane.
2. Epoxy coated nodular iron monolithic casting or stainless steel monolithic casting as scheduled in Section 3.03.
3. Diffuser head casting shall act as a base for the aerator motor.
4. Alignment of the motor to motor base shall be controlled by machined index fittings that engage the P Base of the motor. Diffuser motor arrangements that are dependent upon bolt holes only for alignment are not acceptable.
5. The diffuser head shall absorb all normal and shock loads encountered by the propeller and transmitted to the diffuser head via the motor shaft and lower motor end bell.
6. The diffuser shall have the minimum weight as scheduled in Section 3.03 in order to minimize vibration and provide adequate strength.
7. Low trajectory diffuser will be provided.

F. Flotation
1. Each aerator shall have not less than the reserve buoyancy scheduled in Section 3.03 to ensure stability and provide support flotation required during servicing.
2. Flotation stability shall be provided by design. No counter balancing or ballast of liquid or solid mass or weight displacement shall be acceptable.
3. The float shall be a minimum of 71" in diameter and 12" thick, and shall be fabricated of approved fiberglass construction as later described herein.

4. The float shall be constructed so that all stress imposed from wave action and mooring line to another by pulling across the float in such a manner as not to "flex" the structure. Floats of fiberglass construction must have internal reinforcements to transmit those forces. Mooring connections will not be allowed to stress the fiberglass hull in any way.
5. All floats shall be constructed allowing no voids. Only closed cell polyurethane foam having a minimum 2.0 lbs/ft3 density shall be allowed.
6. All floats shall have a minimum of three mooring points, spaced as shown on Drawings around the outer circumference. No mooring connections will be allowed as imbedments in the upper or lower float covers. Only tension type connections perpendicular to the outer sidewall are acceptable. All mooring connections shall be stainless steel.
7. Floats constructed of polyester fiberglass resins shall have a minimum resin/glass content of 70% resin and 30% glass. A minimum 0.014 inch thick gel coat shall cover the entire outer float shell.
8. A moisture inhibitor, such as N.P.G. (NCO penthal glycol) or equal, and an ultra violet inhibitor, such as UV9 or equal shall be used to protect the float from moisture and sunlight damage.
9. The float construction shall be such that the volute, when encased inside the float, will distribute the load of the entire motor, drive, diffusion head and volute static load plus the entire dynamic load from the propeller thrust and radial forces by spreading these forces uniformly around the full 360 degree circumference of the float's central core. Point connected joints or point stressed connections will not be accepted.
10. The minimum flexural strength of the fiberglass construction materials shall be 26,000 psi and the minimum tensile strength shall be 10,000 psi.

G. Propeller
1. Precision casting of 316 stainless steel, 11-1/2" diameter, specifically designed for the application intended. Self-cleaning type that will not accumulate fibers, rags, or stringy materials. Attachment to the shaft will be by set screws, one through pin and "lock tite."
2. Each propeller blade shall be pitched so that the pitch angle and rake angle are within plus or minus 2 percent of the other blade(s). The propeller shall be pitched so that the drive motor is loaded between 88% and 94% of full load nameplate horsepower.
3. Units using inclined screw impellers will not be acceptable.
4. The propeller must be attached to the motor shaft with a hardened stainless steel pin and set screw. No tapered, threaded shafts with nut fasteners will be acceptable.

H. Volute
1. The propeller shall operate in a volute made of 304 stainless steel and shall be a minimum of 12” in diameter. It shall be round and true so that propeller blade tip clearance is uniform within the volute as it rotates. The

volute shall have a minimum of 3/16 inch wall thickness, and a minimum of four full length stainless steel gussets shall be welded on 90º spacing around the circumference of the volute between the top and bottom flanges.

2. The volute shall have a large machined flange at its top extremity that completely encircles the volute, and this flange shall match a similar flange on the bottom of the diffusion head to provide for a bolted, machined flange-to-flange fit to provide uniform distribution of the dynamic loads generated by the propeller and the static weight of the motor and drive. A 360º machined index in the upper flange shall provide concentric alignment of the propeller in the volute by engaging the inside diameter of the mating flange on the diffusion head. Bolt holes alone will not be acceptable to locate the important alignment of the propeller.
3. Fiberglass volutes or carbon steel volutes that are fiberglass or stainless steel lined are not acceptable.
4. Provide stainless steel draft tube extensions required for proper intake location within the tank as recommended by manufacturer.

I. Electrical Service Cable

1. Each unit shall be furnished with the required footage of four conductor, continuous length (non-spliced) underwater electric service cable. Units with two speed motors shall be furnished with independent service cables for high and low speeds.
2. The aerator manufacturer shall furnish the cable with the motor end sealed into the motor terminal box and wired for 460 volt service. The aerator manufacturer shall be responsible for this watertight seal and electrical connection. The other end of the cable will be wired into the power supply by the installing CONTRACTOR.
3. Only flexible type copper stranded cable with four individually jacketed conductors bound together with a non-hygroscopic filler and sheathed in a PVC. Outer jacket shall be high quality CPE, PVC, TPE or equal, and shall be rated at a conductor operating temperature of not less than 90°C.
4. The cable shall be rated for hard usage outdoor service and shall be resistant to oil, sunlight, ozone, grease, acids, water, abrasion and impact.

J. Mooring

1. The anchor cable shall be installed as recommended by the manufacturer and shown on Drawings so the mixer will have a minimum of lateral movement.
2. The maximum amount of anticipated water level variation is 1 foot.
3. Anchor cable shall be 7 x 19 construction, 304 stainless steel and 3/16-inch diameter.
4. Hardware:
   a. Mooring hardware (thimbles and clips) shall be of 316 stainless steel.
   b. Galvanized hardware is not acceptable.
5. Cable floats:

a. Shall be made so that internal void is filled with closed-cell polyurethane foam of 2.0 lbs/ft^3; density.
b. Floats to be attached to the mooring cable with Ty-wraps.
c. These latches shall be of the clamp type.
d. No embedment into the fiberglass will be allowed.

K. Balancing and Vibrational Analysis
1. Once the power section (consisting of the motor, its support base, extended shaft and propeller) is assembled, the rotating elements of the power section shall be dynamically balanced to 2.0 mils peak to peak maximum amplitude (0.20" per second velocity) measured at the top and bottom motor bearing. Measurements shall be taken at a frequency equal to the motor speed (RPM) and at a frequency equal to the number of propeller blades times the motor speed.
2. Aerators that have their rotating elements factory assembled must be tested for vibrational velocity levels at the factory prior to shipping.
3. Units that are to have the rotating elements field assembled must also be factory balanced and tested. Documentation of the test results and certification that these results do meet this portion of the specifications shall be furnished to the ENGINEER prior to shipment. Such documentation notwithstanding, the units having rotating elements field assembled shall be field tested for vibration velocity levels after final assembly. These tests shall be conducted by the aerator manufacturer, or his duly appointed representative, and these tests shall, at his option, be witnessed by the ENGINEER.

2.03 AERATION PERFORMANCE

A. Oxygen Transfer: Minimum of 3.0 lbs/hp/hr as determined by the unsteady state test technique at the standard conditions of 2.0 ppm dissolved oxygen, 1 atmosphere, and 20ºC.

B. Mixing and Dispersing
1. Aerator to provide sufficient kinetic energy to maintain complete mixing and uniform oxygen dispersion within the respective diameter circles scheduled in Section 3.03.

2.04 COLD WEATHER EQUIPMENT

A. When listed in the schedule in Section 3.03, furnish the following equipment:
1. Heater pack on each aerator, submersible cable with floats to each aerator for heater power, cord grips, boxes, and accessories. Cable shall be the same type as the electrical service cable.
2. Weatherproof temperature sensor and controls for each aerator or for each group of aerators as shown on Drawings.

3. All other hardware and appurtenances necessary for proper cold weather operation.

PART 3 EXECUTION

3.01 INSTALLATION

A. As specifically recommended by the equipment manufacturer.

3.02 START UP SERVICES

A. Provide a factory trained service representative to be present to check field installation and operation.

B. A factory trained service representative to provide a minimum of 4 hours of training to operating personnel on operation and maintenance of aerator equipment.

C. Certify in writing to the ENGINEER that the equipment has been properly installed, fully functional, and ready to use.

3.03 SCHEDULE

A. Number of aerators: Two
1. Horsepower of Unit = 10
2. Equipped with two speed motors = No
3. Provided with cold weather equipment = No
4. Diffuser head material = Stainless Steel
5. Minimum weight of diffuser = 205 lbs
6. Parts = Stainless Steel
7. Float hull material = Stainless Steel
8. Buoyancy reserve capacity = 995 lbs
9. Mooring cable floats = required
10. Site Elevation = 6700 feet above MSL
11. Oxygen Dispersion Diameter = 200’ min

END OF SECTION