INDIGENOUS DESIGN STUDIO + ARCHITECTURE, LLC

8008 PENNSYLVANIA CIR NE
ALBUQUERQUE, NM 87110
T 505.226.2565
F 505.226.2566

PROJECT MANUAL - VOLUME 2

JULY 15, 2022

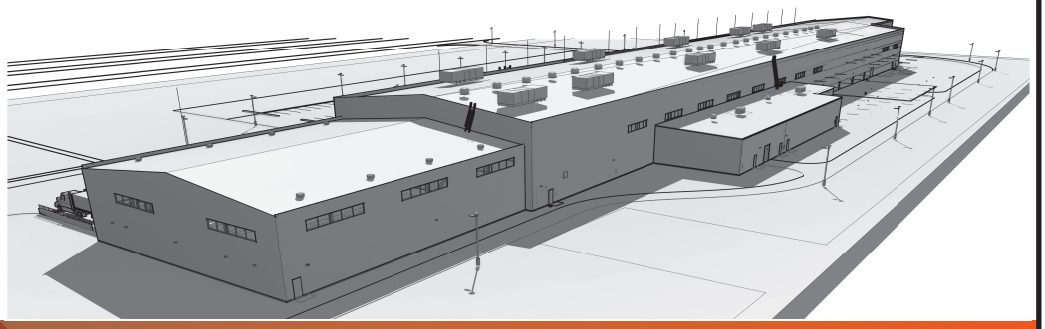
CONSTRUCTION DOCUMENTS

STATE OF NEW MEXICO
TAMARAH R. BEGAY
NO. 5192
07/15/2022
REGISTERED ARCHITECT

SEAL / CERTIFICATION

CHURCH ROCK PHASE II FACTORY

CHURCH ROCK, NEW MEXICO



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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
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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 NFPA 5000 Building Construction and Safety Code, 2018 Edition, the Uniform Plumbing Code, 2018 Edition; the Uniform Mechanical Code, 2018 Edition and the International Fire Code, 2018 Edition, as adopted and interpreted by the State of New Mexico, City of Shiprock, and the National Fire Protection Association (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 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. All utility connections, extensions, and tap fees shall be paid for by the Contractor, unless otherwise specified herein. 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

American Society of Sanitary Engineers

Standards and requirements of local utility companies

National Fire Protection Association Standards

American Society of Mechanical Engineers

American Society of Mechanical Engineers Boiler and Pressure Vessel Codes

Occupational Safety and Health Act

Factory Mutual Engineering and Research

Manufacturers Standardization Society of the Valve and Fittings Industry

National Institute for Certification in Engineering Technologies

1.4 RECORD DRAWINGS

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

1.5 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. See Division 1 for additional submission requirements.

1.6 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.

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.

1.7 FIRE PROTECTION DESIGN REQUIREMENTS

A. A fire protection design analysis is required for all designs and must address the fire protection requirements of the project. The FPE, in conjuction with Architectural Designer of Record, shall be responsible for the fire protection design analysis. Where applicable, the design analysis, as a minimum, shall discuss the following:

1. Building construction type, height, and area limitations, and building separations and exposure protection
2. Classification of occupancy
3. Specific compliance with applicable section(s) of NFPA's National Fire Code
4. Requirements for fire-rated walls, fire-rated doors, fire dampers with their fire-resistive ratings, smoke compartmentalization, smoke barriers, and smoke dampers
5. NFPA 5000 Building Construction and Safety Code
6. Analysis of automatic suppression systems and protected areas
7. Water supplies, including location and connections compatibility with the local fire department
8. Smoke control systems
9. Fire alarm system (the type of alarm system and location of alarm equipment and fire zones)
10. Standpipe systems and fire extinguishers
11. Interior finish ratings
12. Connection to and description of the fire alarm reporting system
13. The various occupancies and hazardous areas associated with the facility
14. Fire Department access

B. At the 100% design submission of plans and specifications, the FPE shall certify in writing that the design is in compliance with the requirements and all applicable

criteria.

1.8 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.

1.9 PRIOR APPROVAL

A. See Division 1 for additional substitutions and product options requirements.

1.10 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 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) year parts and labor warranty, from the date of acceptance by the Owner.

1.11 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.

1.12 ALTITUDE RATINGS

A. Unless otherwise noted, all specified equipment capacities are for an altitude of 5,070 feet above sea level and adjustments to manufacturer's ratings must be made accordingly.

1.13 ELECTRICAL WIRING AND CONTROL EQUIPMENT

A. All wiring and conduit shall be furnished and installed as scheduled in Section 21 0549, 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.

1.14 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.

1.15 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 [and system valve numbers and designations shall be coordinated with existing valve identification. 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.

1.16 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
------ 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 exposed within mechanical equipment spaces shall be semi-rigid plastic identification markers. Each label shall have appropriately color-coded background with printed legend. Directional flow arrows shall be included on label. Labels shall "snap-on" around pipe without the requirement for adhesive or bonding of piping sizes 3/4" through 5". Labels for piping 6" and larger shall be furnished with spring attachment at each end of label. Labels shall be "SETMARK" Type SNA, 3/4" through 5" size and Type STR, 6" and larger, as manufactured by Seton Name Plate Corporation, Brady, or equivalent.

G. 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 background color of the label shall be placed over each end of the label and completely around the pipe.

H. 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.

I. 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 Dry Standpipe	White	Red
Fire Wet Standpipe	White	Red
Fire Combination Standpipe	White	Red

1.17 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.

1.18 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.

1.19 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.

1.20 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 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.

1.21 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.

1.22 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.

1.23 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. 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.

B. See Section 21 0548 for additional requirements for seismic supporting of fire suppression equipment and systems.

1.24 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 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. 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 gyp board sanding and finishing. Unprotected equipment and piping will require special field cleaning by the Contractor prior to acceptance by the Architect.

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 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.

1.25 TRENCHING AND BACKFILLING

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

1.26 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.

1.27 TESTS

A. Tests shall be conducted in the presence of the designated and authorized Owner's Representative. The Contractor shall notify the Architect 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.

1.28 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 two (2) copies of all the literature; each shall be suitably bound in loose leaf book form.

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.

E. Film the instruction and training sessions submit two copies of the DVD.

F. Equipment startup and operational test shall be conducted by the Contractor with the assistance of the representatives from the fire pump manufacturers and fire pump controller manufacturer. Test shall be conducted in the presence of the designated and authorized Owner's Representative.

1.29 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.

1.30 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 210500

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: _____

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 210503 - TRENCHING AND BACKFILLING FOR FIRE SUPPRESSION

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.

B. The Contractor shall provide the services of a qualified underground locator to field locate and mark all existing buried utility lines, public and private, piping, conduits, etc., within the required construction area prior to the start of any trenching or excavation work.

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.

Not Applicable.

See Division 23, Section 23 0503, for applicable requirements.

END OF SECTION 210503

SECTION 210504 - PIPE AND PIPE FITTINGS FOR FIRE SUPPRESSION

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 21 0500 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, seismic restraints, pipe sleeves including sealing and fire safing materials and installation.

PART 2 - PRODUCTS

See Division 21, Section 21 1313 for applicable requirements.

PART 3 - EXECUTION

See Division 21, Section 21 1313 for applicable requirements.

END OF SECTION 210504

SECTION 210505 - PIPING SPECIALTIES FOR FIRE SUPPRESSION

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 21 0500, Common Work Requirements for Fire Suppression.

B. Section 21 0504, Pipe and Pipe Fittings for Fire Suppression.

C. Section 21 0523, Valves for Fire Suppression.

D. Section 21 0549, Fire Suppression and 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.

See Division 23, Section 23 0505, for applicable requirements.

See Division 23, Section 23 0505, for applicable requirements.

END OF SECTION 210505

SECTION 210523 - VALVES FOR FIRE SUPPRESSION

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 21 0500, Common Work Requirements for Fire Suppression.

B. Section 21 0523, Valve Identification for Fire Suppression.

C. Section 21 0504, 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.

See Division 21, Section 21 1313, for applicable requirements.

See Division 21, Section 21 1313, for applicable requirements.

END OF SECTION 210523

SECTION 210548 - VIBRATION AND SEISMIC CONTROLS FOR FIRE PROTECTION

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 and the City of Shiprock.

1.6 PROJECT SEISMIC PARAMETERS

A. The following parameters shall 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	SDS=0.546 SD1=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.

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

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

END OF SECTION 210548

SECTION 210549 - FIRE SUPPRESSION AND ELECTRICAL INSTALLATION COORDINATION

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 21 0500, 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.

Not Applicable.

1.4 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 Pump Systems, including main pump & jacket pump control panels, automatic transfer switches and remote monitoring panels		Div. 21	Div. 21	Div. 26	Div. 21
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 210549

SECTION 211313 - FIRE PROTECTION SYSTEM, AUTOMATIC WET-PIPE SPRINKLER

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.

1.2 RELATED SECTIONS

Section 21 0500	Common Work Requirements
Section 21 0503	Trenching and Backfilling for Mechanical Systems
Section 21 0504	Pipe and Pipe Fittings
Section 21 0505	Piping Specialties
Section 21 0523	Valves
Section 23 0549	Fire Suppression and Electrical Installation Coordination
Section 23 0900	Facility Management System
Section 23 3000	Air Tempering System and Equipment
Section 28 3100	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 1, 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-1, 13, and 5000, 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 1, 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 City of Shiprock.

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

H. Attention is drawn to the fact that in accordance with BIA standards, light hazard occupancy classifications will not be allowed within the project. The minimum classification will be ordinary hazard group one.

I. In accordance with BIA standards, the maximum square footage allowed per zone will be 26,000 ft^2.

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 21 0500 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 Division of Safety and Risk Management (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 21 0500.

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: Ordinary Hazard
   b. Storage Areas: Ordinary Hazard
   c. Equipment Rooms: Ordinary Hazard
   d. Service Areas: Ordinary Hazard

2. Minimum Density Requirements for Automatic Sprinkler Hydraulic Design:

   a. Ordinary Hazard, Group 1 Occupancy: 0.15 gpm over 1500 sf area.
   b. Ordinary Hazard, Group 2 Occupancy: 0.20 gpm over 1500 sf area.
   c. 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. 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 5800 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., in accordance with NFPA 72.

1.12 GENERAL

A. All material and equipment furnished shall be in accordance with the following requirements and NFPA 13. 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 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."

1.13 PIPING MATERIAL

A. All pipe, fittings, hangers, valves, and accessories shall be manufactured in the United States of America.

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

C. Underground piping, to a point 5'0" from the building perimeter, shall be as specified for underground water services in Div. 33 of this Specification.

D. 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.

E. Interior building piping systems 2-1/2” and larger shall be black steel pipe ASTM A120, or A53 Grade A or B, ERWQ or BW, Standard wall, Schedule 40 or Schedule 10. UL and FM approved thin wall (Schedule 10, minimum) ASTM A135 or A795 piping may be utilized for sprinkler system piping 2-1/2” and larger as allowed by NFPA and the Fire Marshal. Piping 2” and smaller shall be Schedule 40 only. Piping installed outside or exposed to outdoor ambient conditions shall be galvanized.

1.14 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. 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 21 0504.

D. Cut grooved couplings, fittings, and gaskets used throughout a system shall be supplied from the same manufacturer and designed for the specific installation. Roll grooved joints will not be accepted.

E. Face bushings and hexagonal bushings shall not be permitted.

F. Threaded pipe and fittings shall be used in all exposed areas.

1.15 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.

1.16 UNIONS AND FLANGES

A. Unions and flanges shall be provided in accordance with Section 21 0504, Pipe and Pipe Fittings. Gaskets shall be as recommended by the manufacturer and suitable for service on which used.

1.17 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. 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.

1.18 VALVES

A. See Section 21 0523, Valves, for general valve requirements. All valves for fire hose fire department connections shall have threads and adapters to match the standard of the City of Shiprock 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. All drain valves shall be made accessible and operable from the floor.

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.

1.19 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.

1.20 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.

1.21 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).

1.22 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.

1.23 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 and

101 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.

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. Provide a metal cabinet with a sprinkler head wrench for each type head.

F. Provide sprinkler head guards throughout the gymnasium, where required by NFPA 13, and where appropriate.

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

H. Sprinkler heads subject to damage and/or located within 7’-0” of the floor and heads located within electrical or mechanical rooms shall be fitted with approved head guards.

I. Areas within reach of unsupervised detainees shall be equipped with institutional type tamper resistant pendant and sidewall sprinkler heads. . Concealed type pendant heads shall be utilized in all other areas of supervised detainee access or unsupervised areas where the ceiling mounted heads are not readily accessible.

J. Sprinkler heads within elevator machine rooms shall be rated for 286°F.

1.24 SYSTEM ACCESSORIES

A. Fire Department Connections: Fire department connections shall be of the type and style shown on the civil and fire protection 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.

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.

1.25 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.

1.26 INSTALLATION

A. General

1. The complete fire protection system shall be installed in accordance with NFPA 13. 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 21 0500 – Common Work Requirements, Section 21 0504 – Pipe and Pipe Fittings, and Section 21 0505 – 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 21 0500, 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.

1.27 EQUIPMENT INSTALLATION

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

1.28 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.

1.29 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. 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. 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. 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.

1.30 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.

1.31 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) shall be included to document the final inspection, operating test, acceptance and placement of system in service.

END OF SECTION 211313

SECTION 220500 - COMMON WORK REQUIREMENTS FOR PLUMBING

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

1.3 CODES AND PERMITS

A. The plumbing work shall be performed in strict accordance with the applicable provisions of NFPA 5000 Building Construction and Safety Code, 2018 Edition; the Uniform Plumbing Code, 2018 Edition; and the Uniform Mechanical Code, 2018 Edition as adopted and interpreted by the State of New Mexico, City of Shiprock, 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 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. All utility connections, extensions, meter pits and meter sets and tap fees for water, storm sewer, sanitary sewer and natural gas shall be paid for by the Contractor, unless otherwise specified herein. 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

Bureau of Indian Affairs Schools Design Handbook

1.4 RECORD DRAWINGS

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

1.5 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. See Division 1 for additional submission requirements.

1.6 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.

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.

1.7 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.

1.8 PRIOR APPROVAL

A. Equipment manufacturers and service providers are listed within the specifications for the work specified in this division.

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.

1.9 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 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.

1.10 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.

1.11 ALTITUDE RATINGS

A. Unless otherwise noted, all specified equipment capacities are for an altitude of 5,070 feet above sea level and adjustments to manufacturer's ratings must be made accordingly.

1.12 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, 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 5800 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°C 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°C.

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.

1.13 ELECTRICAL WIRING AND CONTROL EQUIPMENT

A. All wiring and conduit shall be furnished and installed as scheduled in Section 22 0549, 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.

1.14 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.

1.15 COUPLING GUARDS

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

1.16 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 and system valve numbers and designations shall be coordinated with existing valve identification. 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.

1.17 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
------ 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 exposed within mechanical equipment spaces] shall be semi-rigid plastic identification markers. Each label shall have appropriately color-coded background with printed legend. Directional flow arrows shall be included on label. Labels shall "snap-on" around pipe without the requirement for adhesive or bonding of piping sizes 3/4" through 5". Labels for piping 6" and larger shall be furnished with spring attachment at each end of label. Labels shall be "SETMARK" Type SNA, 3/4" through 5" size and Type STR, 6" and larger, as manufactured by Seton Name Plate Corporation, Brady, or equivalent.

G. 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 background color of the label shall be placed over each end of the label and completely around the pipe.

H. 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.

I. 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
Soft Cold Water	White	Green
Soft Hot Water	Black	Yellow
Industrial (non potable) Cold Water	White	Green
Reverse Osmosis	White	Green
Compressed Air	White	Blue
Roof Drain	White	Green
Sanitary Sewer	White	Green
Storm Sewer	White	Green

1.18 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.

1.19 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.

1.20 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.

1.21 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 24" x 24" 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.

1.22 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.

1.23 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.

1.24 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.

1.25 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.

1.26 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. 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.

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 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.

1.27 TRENCHING AND BACKFILLING

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

1.28 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.

1.29 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.

1.30 EQUIPMENT FURNISHED UNDER OTHER SECTIONS OF THESE SPECIFICATIONS

A. Certain items of mechanical equipment as listed on the drawings and/or specifications will be furnished [under other sections of this specification for mechanical rough-in and connection under Division 22, including plumbing, domestic water and waste, cooling water, compressed air, etc. All required plumbing services, including connection of such services to equipment shall be provided under Division 22.

1.31 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.

1.32 PRESSURE RELIEF DEVICES

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

1.33 TESTS

A. Tests shall be conducted in the presence of the designated and authorized Owner's Representative. The Contractor shall notify the Architect 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.

1.34 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:

Water Softener
Domestic Water Heater

1.35 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 one (1) 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. Film the instruction and training sessions submit two copies of the DVD.

F. 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.

1.36 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.

1.37 CONSTRUCTION PHASING AND SCHEDULE

A. All work furnished and installed under Division 22 of this Specification shall be provided in accordance with the project schedule and phase requirements [as described on the Architectural Drawings and Specifications.

1.38 PLUMBING SYSTEM SHUTDOWN AND REACTIVATION

A. The Contractor shall shutdown existing facility plumbing equipment and piping systems as required for installation of the project plumbing construction work. As a part of the required work, the Contractor shall drain down the existing systems and after completion of new work and pressure testing of systems, the Contractor shall refill the systems and re-establish proper system circulation, remove all air from piping system and equipment, and place system in full and proper operation.

1.39 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 220500

Project:
General Contractor:
Mechanical Contractor:

Date Submitted:
Date of Final Mechanical System:
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 ItemProposed 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:

Name:

Title:

Date:

Company Name:

Address 1:

Address 2:

SECTION 220503 - TRENCHING AND BACKFILLING FOR PLUMBING

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 plumbing work specified herein under Division 22.

B. The Contractor shall provide the services of a qualified underground locator to field locate and mark all existing buried utility lines, public and private, piping, conduits, etc., within the required construction area prior to the start of any trenching or excavation work.

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.

1.4 REFERENCES/STANDARDS

A. OSHA 29 CFR Part 1926, Subpart P.

1.5 TRENCHING AND BACKFILLING

A. General Excavation: The Contractor shall perform all excavation of every description and of any substances encountered, to the depths indicated on the drawings or as otherwise specified. During excavation, 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 backfill shall be removed and wasted. Berming and grading shall be done as may be necessary to prevent surface water from flowing into trenches or other excavations, and any water accumulating therein shall be removed by pumping or by other approved methods. Sheeting and shoring shall be done as required for the protection of the work and for the safety of personnel.

B. Trench Excavation: Trenches shall be of 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 as nearly its full length as practicable. Care shall be taken not to excavate below the depths indicated. Where rock excavation is required, the rock shall be excavated to a minimum overdepth of 4 inches below the trench depths indicated on the drawings or specified. Overdepths in the rock and common excavation shall be backfilled with coarse sand, fine gravel, or otherwise suitable 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 coarse sand, fine gravel, or other suitable materials, as hereinafter specified.

C. The Contractor shall move trucks and equipment on prescribed roads and keep the roads free from mud, dirt and spillage.

D. If additional material is needed for fill on the project, it shall be furnished by the Contractor.

E. Bracing and Bulkheading: In all excavation work the Contractor shall provide necessary underpinning, bracing, or bulkheading to safeguard the work, the present structures, workmen, the public, and the property, and shall assume all responsibility in connection therewith.

F. Backfilling: The trenches shall not be backfilled until all required pressure tests are performed and until the utilities as installed conform to the requirements specified. The trenches shall be carefully backfilled with materials approved for backfilling; free from large clods of earth or stones. The entire depth of trench shall be backfilled in layers, and each layer shall be spread evenly, wetted to optimum moisture and thoroughly mixed to uniform consistency and compacted to the required maximum density obtainable as the same soil, as determined by ASTM D698.

G. All imported fill required under this section will be furnished by the Contractor. Imported fill will be base course material approved for use by the State Highway Department.

H. Fill material shall be free from trash, lumber or any type of debris which may be detrimental to producing the required density in the fill.

I. The earth beneath all sidewalks and concrete slabs shall be backfilled and compacted to at least 8" below any gravel or sub-base material before the placement of gravel or other base material and shall be coordinated with requirements contained within Division 33.

J. All piping not encased in concrete shall be bedded in sand or fine gravel, without rocks or other foreign material. Bedding material shall be placed around the pipe in accordance with manufacturer’s recommendations. The bedding material shall be distributed around pipe to assure full consolidation.

K. In grass and planted areas, the Contractor shall backfill his excavation to approximately 8" below finished grade. Contractor shall coordinate backfill requirements contained in Division 33.

L. Provide density test for trench, backfill in accordance with Division 33 requirements.

END OF SECTION 220503

SECTION 220504 - PIPE AND PIPE FITTINGS FOR PLUMBING

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 22 0500, 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.

See Division 23, Section 23 0504 – Pipe and Pipe Fittings, for applicable requirements.

See Division 23, Section 23 0504 – Pipe and Pipe Fittings, for applicable requirements.

END OF SECTION 220504

SECTION 220505 - PIPING SPECIALTIES FOR PLUMBING

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 22 0500, Common Work Requirements for Plumbing.

B. Section 22 0504, Pipe and Pipe Fittings for Plumbing.

C. Section 22 0523, Valves for Plumbing.

D. Section 22 0700, Plumbing Insulation.

E. Section 22 0549, 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.

See Division 23, Section 23 0505, Piping Specialties.

See Division 23, Section 23 0505, Piping Specialties.

END OF SECTION 220505

SECTION 220523 - VALVES FOR PLUMBING

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 22 0500, Common Work Requirements for Plumbing.

B. Section 22 0504, 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.

See Division 23, Section 23 0523 - Valves, for applicable requirements.

See Division 23, Section 23 0523 - Valves, for applicable requirements.

END OF SECTION 220523

SECTION 220549 - PLUMBING AND ELECTRICAL INSTALLATION COORDINATION

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 22 0500, Common Work Requirements for Plumbing.

B. Section 23 0900, 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.

1.4 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
Pressure Booster Pump Systems		Div. 22	Div. 22	Div. 26	Div. 23
Water Softeners & Other Process Water Equipment		Div. 22	Div. 22	Div. 26	N/A
Facility Management System (FMS) for Automatic Control and/or Monitoring of Plumbing System & Equipment	(2)	Div. 23	Div. 23	Div. 26	Div. 23
Medical Gas System - Alarm Panels, Sensors, Pressure Switches	(3)	Div. 22	Div. 22	Div. 26	Div. 22

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 220549

SECTION 220700 - PLUMBING INSULATION

1.1 REQUIREMENTS

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

B. The Midwest Insulation Contractors Association and Industrial Insulation Standards, Latest Edition, shall be utilized as a standard for the work provided under this specification.

C. Materials shall conform to applicable ASTM standards.

1.2 RELATED SECTIONS

A. Section 22 0500, Common Work Requirements for Plumbing.

B. Section 22 0504, Pipe and Pipe Fittings for Plumbing.

1.3 SCOPE

A. All condensate pipe and fittings, domestic hot water pipe including soft hot water and 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 and soft cold water piping, water piping located outdoors exposed to ambient freezing conditions.

B. 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.

1.6 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^{o}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^{o}F., maximum service temperature 1200^{o}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^{o}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^{o}F., maximum service temperature of 220^{o}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.

1.7 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.

1.8 METAL JACKETING

A. Metal jacket shall be 0.010-inch smooth Type 304 stainless steel, smooth. Provide moisture barrier lining for service temperatures 60°F and less, except where applied over insulation with All Service (ASJ) vapor barrier jacket. Stainless steel jacket shall be installed where specified herein or otherwise indicated on the drawings.

B. Metal jacket shall be 0.016-inch smooth aluminum. Provide moisture barrier lining for service temperatures 60°F and less except where applied over insulation with All Service Jacket (ASJ) vapor barrier jacket. Aluminum jacketing shall be installed where specified herein or otherwise indicated on the drawings.

1.9 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.

1.10 PIPE HANGERS AND SUPPORTS

A. See Specification Section 22 0504 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 22 0504, 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

1.11 PIPE SLEEVES

A. See Specification Section 22 0504 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.

1.12 DOMESTIC HOT WATER PIPING

A. Domestic hot water piping with operating temperatures of 140^{o}F and less, including soft hot water and 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^{o}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.

1.13 DOMESTIC COLD WATER AND ROOF DRAINS

A. Domestic cold water piping including soft 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.

1.14 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.

C. Comply with knee and toe clearances, ADA/ABAAG 306.

1.15 PLASTIC PIPING SYSTEMS

A. Plastic piping systems, including but not limited to polypropylene/CPVC, RO/DI piping, 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.

1.16 METAL JACKETING

A. Metal jacketing shall be installed on all field insulated plumbing equipment and on plumbing piping systems exposed within the mechanical equipment spaces, that are installed exposed below 8 feet above the floor, where exposed to physical damage, on outdoor insulated piping, and where noted on the drawings.

B. The jacketing shall be applied with joints overlapped 2" and located to shed water. Joints and seams shall be caulked with an approved weatherproof caulking when located outdoors. The insulation shall be banded 12" on centers or screwed in place 3" on centers.

C. Fittings and valves shall have insulation covered with metal jacket, as specified herein. Fittings and valves on exterior piping and ductwork shall be covered with metal jacketing to match pipe and duct covers. PVC fitting covers, painted to match adjacent metal jacket, may be used on interior pipes and ducts.

1.17 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, that are installed below 8 feet above the floor, 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.

1.18 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.

1.19 FACTORY INSULATED EQUIPMENT

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

1.20 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.

1.21 HEAT TRACED PIPING

A. All piping installed outdoors subject to freezing which is provided with heat tracing system as specified in Section 22 0505, including domestic water piping exposed to freezing conditions, make-up water piping to Division 22 and Division 23 equipment, including condensate systems, including valves and fittings, shall be insulated with fiberglass sectional pipe insulation, as specified for chilled water piping, and finished with metal jacket. Oversize insulation as required to accommodate electric heat tracing system. Waterproof metal jacket joints and seams with silicone caulking.

END OF SECTION 220700

SECTION 221100 - DOMESTIC WATER PIPING

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 22 0500, Common Work Requirements for Plumbing

B. Section 22 0504, Pipe and Pipe Fittings for Plumbing.

C. Section 22 0505, Piping Specialties for Plumbing.

D. Section 22 0523, Valves for Plumbing.

E. Section 22 0700, Plumbing Insulation.

F. Section 22 6801, Onsite Utilities, Plumbing.

G. Section 23 0900, Facility Management System.

H. Division 33 for Outside Utilities.

1.3 SCOPE

A. A complete domestic cold water, hot water, recirculating hot water, soft water, non-potable water and make-up water system including water heaters, pumps, thermal expansion tanks, water softeners, meters, 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.

1.4 PIPING

A. Domestic water piping including 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. Wrap all underground copper pipe and fittings with minimum 20 mil polyethylene with minimum 50% overlay, provide for taping.

B. Domestic water piping including soft water piping, non-potable water piping above grade within the building 4" and smaller shall be Type L hard drawn copper, ASTM B88.

C. Proper insulating fittings, as specified in Section 22 0504, shall be installed to prevent electrolytic action between steel and copper piping connections.

1.5 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 22 0504.

B. Mechanically formed tee connections and couplings for copper piping system as specified in Section 22 0504, may be utilized where approved.

C. Fittings for galvanized steel pipe shall be screwed Class 150, standard galvanized malleable iron conforming to ANSI B16.3 or Victaulic or equivalent mechanical pipe couplings as specified in Section 22 0505 and furnished with hot dipped galvanized coating for use with grooved piping system and approved for potable water systems.

1.6 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.

1.7 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.

1.8 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. Electric instantaneous water heaters shall be by Chronomite, Eemax, Hubbell, Keltech, Rheem, Stiebel Eltron, State, or equivalent.

C. 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.

D. 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.

E. 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.

F. Hot water distribution temperatures to the food service area shall be set at 140°F. and 110°F to the lavatories and showers.

1.9 VALVES

A. Valves other than automatic control valves are specified in Section 22 0523, Valves.

B. Automatic control valves shall be as specified in Section 23 0900, 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.

1.10 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.

1.11 WATER SOFTENER SYSTEM

A. Domestic water softener system shall be as specified in the Equipment Schedule on the drawings. The Contractor shall furnish the services of a qualified representative of the equipment manufacturer who shall provide all required start-up services, including salt, and shall provide instruction to the Owner's operating personnel in accordance with the requirements contained in Section 22 0500. Salt in sufficient quantity shall be furnished for operation of the water softener for the first one (1) month of operation of the facility after acceptance by the Owner. Manufacturer shall furnish a full one (1) year warranty, including all parts and labor for the water softener system.] System shall be as manufactured by Culligan, Marlow, Pure Water Technologies, Kinetico, or approved equivalent.

1.12 WATER METER

A. All costs, fees, and permits required for the installation of the water meter shall be secured and paid for by the Contractor unless otherwise indicated.

B. See Division 33 for water meters.

C. Water meters shall be installed by the Contractor in accordance with the information shown on the drawings and in the Plumbing Fixture Schedule on the drawings.

D. See Section 23 0900, Facility Management System, for plumbing, meters and instrumentation.

1.13 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 backflow protection.

E. See Section 23 0504 for backflow preventer required for make-up water connections to HVAC systems.

1.14 INSTALLATION

A. Piping installation shall conform to the requirements of Section 22 0500, Common Work Requirements for Plumbing and Section 22 0504, Pipe and Pipe Fittings for Plumbing. Installation of specialties shall conform to the requirements of Section 22 0505, 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 City 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.

1.15 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 prior to substantial completion.

1.16 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.

1.17 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 221100

SECTION 221123 - FACILITY NATURAL GAS SYSTEM

1.1 REQUIREMENTS

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

1.2 RELATED SECTIONS

A. Section 22 0500, Common Work Requirements for Plumbing.

B. Section 22 0504, Pipe and Pipe Fittings for Plumbing.

C. Section 22 0505, Piping Specialties for Plumbing.

D. Section 22 0523, Valves for Plumbing.

E. Section 23 0900, 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.

1.4 REFERENCE / STANDARDS

A. NFPA 54, “National Fuel Gas Code” 2018 edition.

1.5 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 22 0523, Valves for Plumbing. All underground steel piping and fittings shall be protected from corrosion by approved coatings or wrapping materials as specified in Section 22 0504 Pipe and Pipe Fittings for Plumbing.

1.6 FITTINGS

A. Fittings for steel piping 1-1/2" and smaller shall be screwed and fittings for steel piping 2” and larger shall be welded. All piping exposed to the ceiling plenum shall be 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. All piping exposed to the ceiling plenum shall be welded.

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

C. All piping exposed to the ceiling plenum shall be welded.

1.7 VALVES

A. Valves shall be as specified in Section 22 0523, Valves for Plumbing.

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

1.8 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 22 0500. 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.

C. Natural gas meters shall be furnished and installed by the Contractor in accordance with the information shown on the drawings and in the plumbing equipment and fixture schedule on the drawings.

D. See Section 23 0900, Facility Management System, for meters and instrumentation.

E. All natural gas meters shall be preceded by a main gas supply shut-off valve serviceable and accessible outside the building.

1.9 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 and for natural gas fired equipment furnished by the Owner and/or under other sections of this specification 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.

1.10 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 22 0504, Pipe and Pipe Fittings for Plumbing.

1.11 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.

1.12 INSTALLATION

A. Piping installation shall conform to the requirements of Section 22 0500, Common Work Requirements for Plumbing, and Section 22 0504, Pipe and Pipe Fittings for Plumbing. Installation of specialties shall conform to the requirements of Section 22 0505, 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 22 0504, 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.

1.13 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.

1.14 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.

1.15 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.

1.16 TESTS

A. All gas piping shall be pressure tested using air, CO2, or nitrogen in accordance with the applicable codes and regulations, including Uniform Plumbing and Mechanical Code as adopted and interpreted by the City of Shiprock and State of New Mexico, and NFPA No. 54.

END OF SECTION 221123

SECTION 221316 - SANITARY WASTE AND VENT PIPING

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 22 0500, Common Work Requirements for Plumbing.

B. Section 22 0504, Pipe and Pipe Fittings for Plumbing.

C. Section 22 0700, Plumbing Insulation.

D. Division 33 for Onsite Utilities Plumbing.

E. Section 23 0900, 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.

1.4 PIPE AND FITTINGS

A. General: Piping Materials listed below shall bear the label of the testing agency/standard specified.

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

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

Clean

C. 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.
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.

D. Acid resistant waste and vent pipe and fittings:

1. Schedule 40, Chlorinated Polyvinyl Chloride (CPVC), ASTM Cell Class 23447. Pipe and drainage pattern fittings conforming to ASTM F 2618. Charlotte ChemDrain, or equal.
2. Schedule 40 polypropylene fire retardant piping system with heat fusion [below slab] or mechanical joints [above slab], as manufactured by Enfield, GSR-FUS-SEAL or Orion. Polypropylene piping system shall be installed in accordance with Uniform Plumbing Code requirements and shall not be installed through penetrations of fire and smoke rated construction [or within building return air plenums. Fittings shall be drainage pattern to match the piping system.

1.5 JOINTS

A. Hubless cast iron: Heavy duty, shielded, minimum (4) band couplings consisting of elastomeric gasket conforming to ASTM C 564 and 0.008” thick type 304 stainless steel shield.

B. Hub-and-spigot cast iron: Double seal compression type rubber gaskets conforming to ASTM C 564, with adhesive type lubricant, Tyler “LUBRI/FAST” or equivalent.

C. PVC: Two step primer/solvent cement procedure per ASTM D 2855. Adhesive primer shall conform to ASTM F 656 and solvent cement shall conform to ASTM D 2564.

1.6 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.

1.7 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.

B. Non water-based trap seal maintenance devices by Jay R. Smith Mfg. Co., Liquidbreaker – The Green Drain, SureSeal, and TrapGuard as specified on the drawings are approved.

1.8 TRAPS AND TAILPIECES

A. Unless otherwise specified, traps shall be copper-alloy adjustable tube type with slip joint inlet and swivel, not less than 20 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 or plastic as required by the application.

B. Traps and associated trim shall be furnished by the plumbing fixture manufacturer as specified in Section 22 4000 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.

1.9 GREASE INTERCEPTORS

A. Grease interceptors of the sizes indicated shall be of reinforced precast concrete, and shall be installed outside the building. Minimum interceptor size shall be 500 gallon. 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.

B. A solids interceptor shall be installed upstream of the grease interceptor where a food grinder is plumbed through the grease interceptor.

C. Polyethylene solids interceptors shall be seamless, rotationally-molded High Density Polyethylene with minimum 3/8” uniform wall thickness, suitable for above or below grade installation, built in accordance to ASME A112.14.3 (type C) and CSA B481.1, field adjustable riser system, built-in flow control, and optional outlet options as manufactured by Schier Great Basin, Canplas, Zurn Proceptor, or approved equivalent.

1.10 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. Cleanouts for acid resistant piping system shall be compatible material for the required piping system.

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

D. Cleanouts shall be installed at 50’ intervals throughout the entire drainage system.

E. Stainless steel security treble hooks with stainless steel cables/chains and attachments shall be installed in the outlet piping of all secureware fixtures. The Owner shall be provided with 24 spare assemblies.

1.11 INSTALLATION

A. Piping installation shall conform to the requirements of Section 22 0500, Common Work Requirements for plumbing, and Section 22 0504, Pipe and Pipe Fittings for Plumbing. Installation of specialties shall conform to the requirements of Section 22 0505, 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.

1.12 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. Vinyl Flashing: As an option to lead flashing in vents through roof, the Contractor may use vinyl flashing, 20 mil thickness, ASTM C689-62 tear strength, 0.14 #/Ft. equal to Pasco Manufacturing Co., or equivalent. The flashing shall be installed in accordance with the manufacturer's recommendations.

C. 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.

1.13 DRAINS

A. All floor 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. Floor drains receiving discharges contaminated with solids shall be equipped with sediment buckets.

C. 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.

1.14 PVC PIPING SYSTEMS

A. Installation of PVC piping systems within the building shall be in accordance with all applicable plumbing and building codes and ordinances. No exposed piping or fittings shall be installed within the building ceiling space and return air plenums unless the material complies with all code requirements, including required fire and smoke ratings, or is properly protected to meet the intent of the code. Penetrations of fire rated barriers shall be provided with [acid resistant] cast iron as specified in this section, or as otherwise approved and accepted by the applicable code authority. Piping above grade shall be installed with uniform slope and shall be properly supported to avoid sagging or bending of horizontal or vertical lines due to insufficient support or thermal expansion/contraction. All piping shall be supported and installed in strict accordance with manufacturer's recommendations.

B. PVC pipe and fittings exposed within building return air plenums shall be covered with an approved insulation material, as specified in Section 22 0700.

1.15 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 221316

SECTION 221400 - FACILITY ROOF DRAINAGE

1.1 REQUIREMENTS

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

1.2 RELATED SECTIONS

A. Section 22 0500, Common Work Requirements for Plumbing.

B. Section 22 0504, Pipe and Pipe Fittings for Plumbing.

C. Section 22 0700, Plumbing Insulation.

D. Division 33 for onsite plumbing utilities.

1.3 SCOPE

A. A complete primary and secondary roof drainage system and associated miscellaneous accessories, including any required modifications to the existing building systems. 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.

1.4 PIPING

A. Pipe, fittings and couplings below grade or slab-on-grade shall be service weight cast iron no hub or bell and plain end pipe, coated inside and outside, conforming to ASTM A-74 and 87 Standards, or polyvinyl chloride (PVC) sewer pipe Schedule 40, conforming to ASTM D3034.

B. Pipe, fittings and couplings above slab on grade shall be either service weight cast iron no hub or bell and plain end pipe, coated inside and outside, conforming to ASTM A-74 and 87 Standards, or polyvinyl chloride (PVC) sewer pipe Schedule 40, conforming to ASTM D3034.

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.

1.5 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.

B. Fittings for galvanized steel pipe shall be screwed galvanized cast iron or malleable iron drainage pattern or Victaulic type ductile iron drainage pattern fittings with mechanical couplings as specified in Section 22 0504.

C. Fittings for DWV copper piping shall be solder type copper or brass.

D. Fittings for PVC piping system shall be Schedule 40 drainage pattern, solvent cement type conforming to ASTM B-2855 or elastomeric seal type conforming to ASTM D-3212.

1.6 JOINTS

A. Joints for cast iron pipe and fittings shall be suitable to match the required piping system and shall be either lead and oakum, or 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.

B. Joints for galvanized steel shall be threaded, made with approved joint compound.

C. Joints for copper shall be soldered using 95-5 composition tin-antimony solder with non-corrosive flux.

D. Joints for PVC piping system shall be either solvent cement type conforming to ASTM D-2855 or elastomeric seal type conforming to ASTM D-3212, except all joints above grade shall be solvent cement.

1.7 DRAINS

A. Roof drains and overflow roof drains shall be Froet, J. R. Smith, Josam, Mifab, Sioux Chief, Wade, Watts, Zurn, 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.

1.8 CLEANOUTS

A. Cleanouts shall be as manufactured by Froet, J. R. Smith, Josam, Mifab, Sioux Chief, Wade, Watts, Zurn, 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.

1.9 ACCESSORIES

A. Refer to Section 22 1316, Sanitary Waste & Vent Piping, for roof flashing requirements.

1.10 INSTALLATION

A. Piping installation shall conform to the requirements of Section 22 0500, Common Work Requirements for Plumbing, and Section 22 0504, Pipe and Pipe Fittings for plumbing. Installation of specialties shall conform to the requirements of Section 22 0505, Piping Specialties for Plumbing.

B. Roof 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 22 1300.

1.11 PVC PIPING SYSTEMS

A. Installation of PVC piping systems within the building shall be in accordance with all applicable plumbing and building codes and ordinances. No exposed piping or fittings shall be installed within the building return air plenums unless the material complies with all code requirements, including required fire and smoke ratings, or is properly protected in a manner approved by the administration authority. Penetrations of fire rated barriers shall be provided with cast iron as specified in this section, or as otherwise approved and accepted by the applicable code authority. Piping above grade shall be installed with uniform slope and shall be properly supported to avoid sagging or bending of horizontal or vertical lines due to insufficient support or thermal expansion/contraction. All piping shall be supported and installed in strict accordance with manufacturer's recommendations.

B. PVC pipe and fittings exposed within building return air plenums shall be covered with an approved insulation material, as specified in Section 22 0700.

1.12 TESTS

A. The roof 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 221400

SECTION 224000 - PLUMBING FIXTURES AND TRIM

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 22 0500, Common Work Requirements for Plumbing.

B. Section 22 0504, Pipe and Pipe Fittings for Plumbing.

C. Section 22 1100, Domestic Water Piping.

D. Section 22 1316, Sanitary Waste and Vent Piping.

1.3 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. Loose key angle 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 for water closets shall be low water consumption type 1.6 gallon per flush 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. Furnish special trim for concealed installation with push-button and/or electronic sensor operation as specified in the Plumbing Fixture Schedule on the drawings. Flush valves shall be American Standard, Delany, Delta, Sloan Regal, Sloan Royal, Zurn, Toto, or equivalent.

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, Jones Stephens, Olsonite, Sperzel, or equivalent.

E. Floor mounted mop sinks and shower floors 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, Fiat, Mustee, Stern-Williams, Zurn, or equivalent. All mop sink faucets shall be equipped with inlet checkstops.

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, Intersan, 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. Drinking fountains shall be as specified on the Plumbing Fixture Schedule on the drawings and as manufactured by Acorn Aqua, Elkay, Guardian, Halsey, Haws, Murdock, Oasis, Sunroc, Taylor 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, Prier, or equivalent. Handles, if specified shall be constructed of metal or brass and finished to match valve unit. Hose bibs installed restrooms and locker rooms shall be installed behind access doors with cylinder locks.

I. Shower valves and mixing valves shall be pressure balancing type as specified on the Plumbing Fixture Schedule on the drawings, and as manufactured by Powers, Leonard, Lawler, Speakman, Symmons, Bradley, or equivalent. Shower heads shall be fitted with vandal-resistant trim.

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.

K. Secureware fixtures shall be fabricated of 14 gauge, stainless steel construction, fully

welded seams, with maximum flush rates of 1.6 GPF and 0.5 GPM flow rates. Fixtures shall be as specified on the Plumbing Fixture Schedule on the drawing and as manufactured by Acorn, Metcraft, Willoughby, or equivalent.

1.4 FAUCETS

A. Plumbing fixture faucets shall be electrically actuated, 0.5 GPM, 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, Delta, Moen, Speakman, T&S Brass, Zurn, or equivalent, and shall be commercial grade.

1.5 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 20 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, offset style, 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.

1.6 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 NFPA 5000, Building Construction and Safety 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 top of 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 spouts shall be no higher than 36” measured from the floor or ground surface to the spout outlet.

1.7 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.

1.8 FIXTURE CARRIERS

A. Fixture carriers shall be provided for all wall hung plumbing fixtures, including water closets, 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. Water closet carriers shall be horizontal or vertical, single or back-to-back units as required for the fixture installation and piping arrangement, and shall be adjustable.

B. Single water closet carriers shall have factory installed rear hold down lugs and anchor foot to provide cantilever support.

C. 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.

D. 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.

E. 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.

1.9 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.

1.10 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.

1.11 CLEANING

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

END OF SECTION 224000

SECTION 230500 - COMMON WORK REQUIREMENTS FOR HVAC

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. See Division 23 for Facilities Management System.

1.2 INDEX OF SPEC SECTIONS FOR THIS DIVISION

23 0500	Common Work Requirements for HVAC
23 0503	Trenching and Backfilling
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 0900	Facility Management System for DDC Controls
23 2313	Refrigerant Piping System and Equipment
23 3000	Air Tempering System and Equipment

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: Navajo Nation
2. Architect: Indigenous Design Studio + Architecture
3. Engineer: Bridgers & Paxton
4. 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.
5. 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 2015 International Building Code, the 2015 Uniform Plumbing Code, and the 2015 Uniform Mechanical Code, as adopted and

interpreted by the State of New Mexico and City of Gallup, 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 SUBMITTAL

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

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.

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 information on warranties.

1.11 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 5,070 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. 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.

U. 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.

1.12 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: 460 V, 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°C or 1.0 SF at 65°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.

1.13 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.

1.14 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

Service/Legend	Letter Color	Background Color	Tape Banding Color
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

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.

1.15 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. Refer to other sections of this specifications for inmate areas and security/detention access door.

D. 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.

1.16 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.

1.17 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. Refer to architectural specifications for access doors in secure and inmate area.

I. 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.

J. 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.

K. 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.

L. 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.

1.18 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. The unique design features of this project will necessitate that the contractor for this division provide greater than normal levels of coordination and cooperation with other disciplines.

E. 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.

1.19 EQUIPMENT SUPPLIED BY OTHERS

A. Certain items of mechanical equipment as listed on the Drawings and/or Specifications will be furnished under other sections of this Specification for mechanical rough-in and connection under Division 23, including plumbing, domestic water and waste, process cooling water, compressed air, exhaust, etc.. All required mechanical services, including connection of such services to equipment shall be provided under Division 23.

1.20 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.

1.21 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.

1.22 SEISMIC RESTRAINTS

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. Where mechanical equipment, piping, and ductwork are connected to the building structure, exact method and means of attachment to the structural system shall be approved.

B. See Section 23 0549 for requirements for seismic supporting of mechanical equipment and systems. Equipment and associated components including ductwork, and piping. Refer to Mechanical Equipment schedules for equipment listed as having a Seismic Importance Factor Ip=1.25.

1.23 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.

1.24 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:

Water Softener
Domestic Hot Water Heaters
Air Handling Units
Fans
Facility Management System (See Specification Section 23 0900)

1.25 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.

1.26 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 the DVD.

1.27 RECORD DRAWINGS

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

1.28 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."

1.29 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 230500

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	_____	Process Piping
_____	Compressed Air	_____	Nitrogen
_____	Natural Gas	_____	Vacuum
_____	Other	_____	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	_____	Condenser Water
_____	Hot 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	_____	Condenser Water
_____	Hot Water	_____	Non-potable Water
_____	Steam	_____	Domestic Hot Water
_____	Condensate	_____	Domestic Cold Water
_____	Fire Protection	_____	Acid Waste and Vent
_____	Sanitary Sewer and Vent	_____	Heat Recovery Piping
_____	Roof and Overflow Drains	_____	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.

SECTION 230503 - TRENCHING AND BACKFILLING

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 HVAC work specified herein under Division 23.

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.

1.4 TRENCHING AND BACKFILLING

A. General Excavation: The Contractor shall perform all excavation of every description and of whatever substances encountered, to the depths indicated on the drawings or as otherwise specified. During excavation, 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 backfill shall be removed and wasted. Berming and grading shall be done as may be necessary to prevent surface water from flowing into trenches or other excavations, and any water accumulating therein shall be removed by pumping or by other approved methods. Sheeting and shoring shall be done as required for the protection of the work and for the safety of personnel.

B. Trench Excavation: Trenches shall be of 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 as nearly its full length as practicable. Care shall be taken not to excavate below the depths indicated. Where rock excavation is required, the rock shall be excavated to a minimum overdepth of 4 inches below the trench depths indicated on the drawings or specified. Overdepths in the rock and common excavation shall be backfilled with coarse sand, fine gravel, or otherwise suitable 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 coarse sand, fine gravel, or other suitable materials, as hereinafter specified.

C. The Contractor shall move trucks and equipment on prescribed roads and keep the roads free from mud, dirt and spillage.

D. If additional material is needed for fill on the project, it shall be furnished by the Contractor.

E. Bracing and Bulkheading: In all excavation work the Contractor shall provide necessary underpinning, bracing, or bulkheading to safeguard the work, the present structures, workmen, the public, and the property, and shall assume all responsibility in connection therewith.

F. Backfilling: The trenches shall not be backfilled until all required pressure tests are performed and until the utilities as installed conform to the requirements specified. The trenches shall be carefully backfilled with materials approved for backfilling; free from large clods of earth or stones. The entire depth of trench shall be backfilled in layers, and each layer shall be spread evenly, wetted to optimum moisture and thoroughly mixed to uniform consistency and compacted to the required maximum density obtainable as the same soil, as determined by ASTM D698.

G. All imported fill required under this section will be furnished by the Contractor. Imported fill will be base course material approved for use by the State Highway Department.

H. Fill material shall be free from trash, lumber or any type of debris which may be detrimental to producing the required density in the fill.

I. The earth beneath all sidewalks and concrete slabs shall be backfilled and compacted to at least 8" below any gravel or sub-base material before the placement of gravel or other base material and shall be coordinated with requirements contained within Division 2.

J. Piping below roadways or service drives buried at a depth of less than 48" shall be protected with a reinforced concrete slab above the piping, either at grade or below the final grade as directed by the Architect.

K. All piping not encased in concrete shall be bedded in sand or fine gravel, without rocks or other foreign material. Bedding material shall be placed around the pipe in accordance with manufacturer’s recommendations. The bedding material shall be distributed around pipe to assure full consolidation.

L. In grass and planted areas, the Contractor shall backfill his excavation to approximately 8" below finished grade. Contractor shall coordinate backfill requirements contained in Division 2.

M. The Contractor shall protect from damage all existing underground indicated on the Contract Drawings Any damage to such existing utilities shall be repaired by the Contractor without additional costs to the Owner.

N. Provide density test for trench, backfill in accordance with Division 2 requirements.

END OF SECTION 230503

SECTION 230504 - PIPE AND PIPE FITTINGS

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 furnished under Division 23 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 23 0500, 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, seismic restraints, pipe sleeves including sealing and fire safing materials and installation.

1.4 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.

B. Pipe fittings for steel piping systems shall be weld, screwed or mechanical couplings. 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 couplings and fittings as manufactured by Victaulic, Tyco-Grinnell, or equivalent may be utilized for steel piping systems in lieu of butt weld fittings, as specified in the applicable Sections of this Specification. Couplings shall consist of ductile or malleable iron housing, with gasket, and nuts and bolts required to secure the unit. Gaskets shall be molded of synthetic rubber or other compound as recommended by the manufacturer for the fluid application including required pressure and temperature operating ranges. Fittings utilized in conjunction with Victaulic type piping system shall be manufacturer's full flow cast iron, malleable iron, or steel fittings with grooves designed to accept mechanical couplings. All piping shall be prepared in accordance with manufacturer's specifications, furnished for factory or field installed roll grooves without metal removal. Square cut grooves will not be permitted. Assembly of couplings, fittings and piping shall be in accordance with manufacturer's published instructions. Gaskets, pipe ends, fittings and coupling housings shall be properly lubricated with water-based type lubricant furnished by the coupling manufacturer. Couplings shall be Victaulic Style 07 "Zero-Flex" or equivalent, rigid coupling through 24" size. For applications in conjunction with connections to items of equipment such as boilers, water chillers, cooling towers, etc., Victaulic Style 75 or equivalent couplings shall be utilized. Adapter connections between Class 125 and 150 flanged components and grooved piping system shall be made utilizing Victaulic Style 741 and 742 or equivalent flange adapter. Branch and tap connections up to one-half the size of the main may be made utilizing Victaulic Style 72 or equivalent outlet couplings and Style 920 or 921 or equivalent branch outlet connections.

F. 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.

G. Bronze flanges, Class 125 and Class 150, shall conform to ANSI B16.24.

H. Cast iron fittings for cast iron sanitary soil, waste, and venting piping systems shall be as specified in Division 22.

I. Ductile iron fittings for ductile iron water service piping systems shall be as specified in Division 22.

1.5 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.

1.6 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.

1.7 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.

1.8 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, Erico, 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 and Table No. 4 for PVDF 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"	6.5	6	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. 4
MAXIMUM SUPPORT SPACING FOR PVDF PIPING SYSTEMS

SCHEDULE 80 PVDF - MAXIMUM SPACING
OPERATING TEMPERATURE (DEGREE F)

Size	70 & less	100	140	180	200	250
1/2"	3	3	2.5	2.5	2	2
3/4"	3	3	3	3	2.5	2.5
1"	3.5	3	3	3	2.5	2.5
1-1/4"	4	3.5	3.5	3	3	3
1-1/2"	4.5	4	4	3.5	3.5	3
2"	5.5	5	4.5	4	3.5	3.5
2-1/2"	5.5	5	4.5	4.5	4	3.5
3"	5.5	5.5	5	4.5	4	4
4"	6	6	5.5	5	5	4.5

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. Un-insulated 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, and for 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, Erico, 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, Erico, 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. See Section 23 0505 for expansion joints, expansion compensators, pipe guide and pipe anchors.

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. Hangers for insulated domestic water piping and roof drain piping systems may be installed under 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, Erico, or equivalent. Grinnell Fig. 160, Erico, 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 Grinnell Fig. 131, Erico, C-clamps Grinnell Fig. 86, Erico, or equivalent may be utilized for attachment of light loads as approved by the Structural Engineer. Attachment to wood construction shall be by means of wood screws or lag bolts.

1.9 PIPE SLEEVES

A. Pipe sleeves in concrete and masonry construction, footings and beams shall be Schedule 40 black steel pipe through 10”, standard wall thickness for sizes 12” and larger, ASTM A 53, A 106, or A 120.

1. For sleeve installation below grade in cast in place concrete wall or floor and masonry construction, sleeves shall be GPT type WS sleeves with minimum 2” water-stop collar or equivalent. The sleeves shall be provided free of welding slag.

The water stop collar shall be welded all around on both sides to the sleeve at the point on the sleeve that positions it at the midpoint of the wall. Sleeve shall be primed inside and outside with Sherwin Williams Water Base Red Primer, or approved equivalent.

B. Pipe sleeves in gypsum board construction shall be galvanized steel metal, minimum 24 gauge; round tube closed with welded longitudinal joint and flanges on both sides.

C. Pipe sleeves shall be furnished and set by the Contractor and they 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.

D. Pipe sleeves shall be installed and properly secured in place at all points where pipes pass through gypsum board stud walls, concrete, and masonry construction and at all fire and smoke rated walls and partitions.

E. 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.

F. Sleeves shall be not less than 1" or more than 2" larger in diameter than the pipe to be installed.

G. 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".

H. Un-insulated 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 fire stop sealant materials.

I. Insulated piping passing through fire walls and smoke walls shall be provided with Calcium Silicate pre-formed pipe insulation of thickness to match adjacent piping, extending minimum 1-inch beyond sleeve in each direction.

1. For penetrations through concrete or masonry walls/floors, the space between the piping sleeve and insulation shall be sealed airtight with UL approved firestop sealant and packed with minimum 4” thickness mineral wool (minimum 4 pcf density) tightly packed and recessed to accommodate sealant.
2. For penetrations through gypsum board wall construction, both sides of the annular space between the insulation and sleeve shall be sealed with UL approved firestop sealant.

J. Penetrations of gypsum board sound walls and air plenum separators shall be caulked airtight with an approved UL firestop sealant.

1.10 PIPE SLEEVE SEAL SYSTEMS

A. Provide pipe sleeve seal systems by one of the following:

1. Link-Seal Modular Wall Penetration Seal as manufactured by GPT.
2. Metraflex Company
3. Proco Products, Inc.

B. Description: Modular sealing element unit, designed for field assembly, for filling annular space between piping and sleeve.

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: Plastic, reinforced nylon polymer
3. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements.

C. Pipe sleeve seal system shall be utilized at all exterior wall penetrations.

D. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

1.11 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.

1.12 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.

1.13 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.

1.14 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 23 0505 for expansion joints, expansion compensators, pipe guides and pipe anchors.

1.15 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.

1.16 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.

1.17 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 230504

SECTION 230505 - PIPING SPECIALTIES

1.1 REQUIREMENTS

A. Furnish and install all piping specialties necessary for satisfactory operation of the systems. Conform to 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 23 0500, Common Work Requirements.

B. Section 23 0504, Pipe and Pipe Fittings.

C. Section 23 0523, Valves.

1.3 SUBMITTAL DATA

A. Furnish complete submittal data for all piping specialties including manufacturer’s specifications, performance characteristics, ratings, installation instructions, certifications and approval of listing agencies, wiring diagrams, and selection analysis.

1.4 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 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, or equivalent.

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, or equivalent.

1.5 PRESSURE GAUGES

A. 2.5-inch glycerin filled, SS case, 1.5% accuracy, dual scale (PSI & KPA), bronze bourdon tube and 0.25-inch NPT connection, brass snubber with properly selected filter disc for the application, and needle valve with knurled brass or ABS plastic handle. Provide multiple needle valves where a single pressure gauge is used to measure pressure at multiple points. Provide siphon for steam gauges. Winters, Weiss, Marshalltown, Ashcroft, Trerice, Weksler, or equivalent.

B. Select pressure range as indicated on the drawings, or if not indicated select so that the normal operating pressure is approximately 50% of the scale range. Provide compound and vacuum gauges where required by the application.

C. Install gauges so they are easily readable from normal operator level. Where the sensing location is not convenient to the operator, install the gauge and needle valves at a location easily read from normal operator level, extend piping from there to the sensing point on the main pipe, and provide a ball valve for isolation at the main. In addition, provide drain and vent valves to facilitate removing air and water from the sensing line.

1.6 THERMOMETER AND THERMOMETER WELLS

A. Either liquid filled or digital type, vari-angle, 3-1/2" stem for pipe sizes through 6" and 6" stem for pipe sizes 8" and larger, dual scale (degrees F & C), separable brass socket, extension neck where installed in insulated piping, and accuracy 1% of range. Winters, Weiss, Moeller, Trerice, Weksler, Duro, or equivalent.

1. Liquid Filled Type: 9" case, straight form, V-shaped, high pressure die cast aluminum, baked enamel finish, with heavy glass-protected front firmly secured with spring action, and organic liquid filled magnifying lens. Winters 9IT or approved equal.
2. Digital Type: May be used both indoors or in outdoor locations not exposed to

sunlight, high impact ABS plastic housing, suitable for operation at 16 Lux. Winters 9IT or approved equal.

B. Ranges: Provide the following ranges except where otherwise indicated:

Domestic Hot Water	30-180 degrees F

1.7 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 23 0523. Provide brass hose connection and plug on valve outlet.

1.8 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.

1.9 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 23 0523. 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.

1.10 TEMPERATURE AND PRESSURE TEST PLUGS

A. 0.25 or 0.5-inch NPT with brass body, EPDM core, and brass gasketed cap. Winters, Peterson, or approved equal. Supply one pressure/temperature test kit with two 4" Duro #105 pressure gauges of 1% accuracy and ranges as required by application; and two 2" Tel-Tru #39R Bi-metal thermometers with 8" stem, 1% accuracy, and ranges as required by the applications; and a protective carrying case.

1.11 AUTOMATIC FLOW LIMITING VALVES

A. To maintain constant flow within 5 percent over a range of 2-32 psid. Bronze or cast iron

body, stainless steel cartridges, two pressure readout ports with quick disconnect valves and caps, SS identification tag marked with rated flow. Valves through 2 inch size shall be threaded connection, valves over 2 inches shall be wafer type; 150 psig rated. Supply one readout kit including flow meter, hoses and flow charts all contained in carrying case. Size valves for required flows. Griswold, FDI, or approved equal.

1.12 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 brass 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.

1.13 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.

B. Expansion Tank materials shall be compatible with Propylene Glycol.

1.14 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.

1.15 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.

1.16 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.

1.17 WATER REDUCED PRESSURE BACKFLOW PREVENTERS

A. Furnish and install water reduced pressure backflow preventer, as approved and accepted by the City of Alamogordo, 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 Alamogordo, State of New Mexico requirements for access for testing and inspection.

C. See Division 33, 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.

1.18 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. See Section 23 0500, Common Work Requirements, and Section 23 0549, HVAC and Electrical Installation Coordination, for requirements associated with electrical control and power wiring for solenoid valves. Furnish hazardous duty enclosure where required by the application.

1.19 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 FLX, low temperature, heating cable rated at 150^{o}F maximum maintenance temperature and suitable for 185^{o}F maximum exposure temperature, or Type HTSX medium temperature heating cable rated at 250^{o}F maximum maintenance temperature and suitable for 420^{o}F maximum exposure temperature, as required by the application and as manufactured by Thermon, 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. Long term stability via service life performance test per IEEE 515 Std; latest edition.

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. End termination, splice and tie kits shall be provided above insulation for maintenance accessibility. Furnish ambient sensing thermostat control NEMA 4 (water-tight) enclosures for freeze protection applications to energize all heat tracing circuits from a central freeze protection control panel, 1/2 inch NPT conduit hub, SPST switch with required rating at 115 VAC through 5 KW systems capacity and **277 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^{0}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^{o}F minimum during the winter based upon an outdoor design temperature of 0^{o}F with 15 MPH wind velocity, and the normal system fluid operating temperature. See Section 22 0700, Plumbing Systems Insulation, and Section 23 0700, Mechanical Systems 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; coordinate with Section 22 0700 and Section 23 0700.

E. See Section 23 0500, Common Work Requirements, Section 22 0549, Plumbing and Electrical Installation Coordination, and Section 23 0549, HVAC and Electrical Installation Coordination, for requirements associated with electrical control and power wiring. Each heat tracer circuit shall have EPDM style breakers or controllers for ground fault protection.

F. Non-metallic pipe applications shall have one (1) layer of aluminum tape below and above the heater, run longitudinally to enhance heat transfer into non-metallic piping systems.

G. Package heat tapes with integral thermostat and "press-to-test" device may be utilized for small freeze protection systems, subject to review and acceptance by the Architect.

DESIGNER TABLE			
Pipe Size, In.	Insulation Thickness	Cable Type	No. of Passes
0.5 to 0.75	See 2207 00 & 23 0700	Min. 3 In./Ft.	1
1.0 to 2.00	See 22 0700 & 23 0700	Min 3 In./Ft.	1
3.0	See 22 0700 & 23 0700	Min 5 In./Ft.	1
4.0 to 6.0	See 22 0700 & 23 0700	Min 5 In./Ft.	1
8.0 to 10.0	See 22 07 0 & 23 0700	Min 10 In./Ft.	1
12.0 to 14.0	See 22 0700 & 23 0700	Min 8 In./Ft.	2
Coordinate with Division 26 for quantity of circuits.			

1.20 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 850ºF, 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.

1.21 PIPE ANCHORS

A. Pipe anchors shall be constructed of welded steel as detailed on the drawings.

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.

1.22 INSTALLATION

A. All specialties shall be installed in accordance with the best standard practices and as recommended by the manufacturer.

B. Install thermometers so they are easily readable from operator level.

C. 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.

1.23 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.

1.24 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.

1.25 TEST AND ADJUSTMENT

A. Field adjust all water pressure regulating valves, flow switches, water level controls, and specialties to provide required system operation.

B. Field test and verify the operation of all safety devices including water **[and steam]** relief valves and temperature and pressure relief valves.

1.26 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 230505

SECTION 230523 - VALVES

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 23 0500 for Common Work Requirements for HVAC.

B. Section 23 0523 for Valve Identification.

C. Section 23 0504 for Pipe and Pipe Fittings.

D. Section 23 2313 for Refrigerant Piping System.

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, Tyco-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, Tyco-Grinnell, Victaulic, Nibco, or Dezurik, or equivalent. Butterfly valves may be used for closed circuit chilled water, heating hot water (200^{o}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 furnished under Division 22 and 23, of the same type, shall be products of a single manufacturer.

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.

1.5 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.

1.6 BUTTERFLY VALVES

A. Valves 2-1/2" and larger shall be full lug pattern, ASTM A-126, Class B cast iron body, 416-SS stems, aluminum/bronze disc, EPDM liner and seats (-30^{o}F to 275^{o}F) 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.

1.7 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.

1.8 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 smaller and manual gear operator with hand wheel for valves 5" and larger.

1.9 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.

1.10 MANUAL AIR VENTS AND DRAIN VALVES

A. For manual air vents and drain valves, see Specification Section 23 0505, Piping Specialties.

1.11 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 230523

SECTION 230549 - HVAC AND ELECTRICAL INSTALLATION COORDINATION

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 23 0500, Common Work Requirements for HVAC.

B. Section 23 0900, 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 23 according to Table 1 on the following page.

1.4 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 less than 50 volts. Div 26 for greater than 50 volts
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
Fan Coil Units Including Duct Heaters, Return Air Dampers		Div. 23	Div. 23	Div. 26	Div. 23
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 23, Div 26. Div. 28
Fan Coil Unit Condensate Float Switches		Div. 23	Div. 23	N/A	Div. 23
Supply, Return & Exhaust Fan with unit mounted 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
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 230549

SECTION 230550 - VARIABLE FREQUENCY DRIVES

1.1 REQUIREMENTS

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

1.2 RELATED SECTIONS

A. Section 230500 for Common Work Requirements for HVAC.

B. Section 233000 for HVAC Air Distribution Systems and Equipment.

C. Section 230593 for Testing, Adjusting and Balancing.

D. Section 230900 for Facility Management System.

E. Division 22, Section 220550, for plumbing variable frequency drives.

F. See Section 013515, LEED Certification Procedures.

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 580.

1.4 SUBMITTALS

A. Refer to Sections 230500 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.

1.6 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 an 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.

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.

10. 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.
11. 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 VFD's.
12. Drive must be designed for against the wall and/or floor mounted arrangements, as required by the project installation requirements.
13. 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.
14. 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.
15. 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.
16. Furnish terminal strip for external interlocks, isolated from the line and ground.
17. 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.
18. 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.

19. 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.
20. 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.

21. The VFD shall have input line fuses mounted in drive enclosure.
22. 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.

C. The VFD shall have a programmable digital operator's keypad located in the front door of the drive enclosure which shall include the following features and requirements.

1. All VFD's 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.
2. 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.
3. 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.
4. 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.
5. 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.
6. 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 VFD's.
7. The VFD shall have a manual speed control integral to the keypad.
8. Analog meter - output percent of maximum speed.
9. 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.
10. 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.

11. 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.
12. All wires to be individually numbered at both ends for ease of troubleshooting.

D. 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):

1. Output Frequency
2. Motor Current
3. Calculated Motor Torque
4. Calculated Motor Power
5. DC Bus Voltage
6. Output Voltage
7. Heatsink Temperature
8. Analog Input Values
9. Keypad Reference Values
10. Elapsed Time Meter
11. kWh Meter

E. 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.

F. 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.

1.7 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.

1.8 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:

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.

1.9 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°C - NEMA 1 and 12 indoor enclosures: 1 thru 50 HP, 480 and 230 volt shall be capable of continuous operation as per VFD manufacturers documented/submittal data or VFD musts be oversized.
2. 0 to 40°C - NEMA 1 and 12 indoor enclosures: 60 thru 550 HP, 480 and 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°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).

1.10 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 VFD's 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 230550

SECTION 230593 - TESTING, ADJUSTING AND BALANCING OF MECHANICAL SYSTEMS

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 250 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:

1. Energy Balance & Integration
2. Kirk Air Co.
3. Native Air
4. N-Demand Test and Balance LLC
5. Air Moving Equipment Company

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. 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.

1.7 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.

1.8 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.

1.9 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.

1.10 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. 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. 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.

1.11 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	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.

1.12 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.

1.13 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.

1.14 AIR HANDLING SYSTEMS – SPECIAL APPLICATIONS

A. 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.

B. 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 230593

SECTION 230700 - MECHANICAL SYSTEMS INSULATION

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.

1.6 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.

1.7 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.

1.8 DUCTWORK INSULATION

A. Type D-1, Fiberglass Blanket: Factory fabricated insulation and FSK jacket assembly suitable for applications from 40-250°F, 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 75°F, NRC 1.36, suitable for unfaced side at up to 450°F and faced side at up to 150°F. 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 250°F, 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 1800°F. Unifrax Fyre-Wrap 0.5 plenum insulation.

G. Type D-7 – Fire Rated Ductwork: Suitable for continuous operation at 1800°F, 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

1.9 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.

1.10 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 +150^{o}F. 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.

1.11 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.

1.12 SPECIAL APPLICATIONS

A. Handicap Lavatory Insulation Kit: Handi-Lav-Guard insulation kit per ANSI A117.1 with flexible vinyl finish.

1.13 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.

1.14 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, (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: N/A
5. Temperature Range TR-5: N/A
6. Temperature Range TR-6: N/A
7. Temperature Range TR-7: N/A

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

1.15 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.

1.16 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.

1.17 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 230700

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, Heat Pumps, Blower Coils and Low Velocity AHU's	Indoor	All	D1	1.5	1, 3
Return Rectangular Ductwork upstream of Fan Coil Units, Heat Pumps, 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 230900 - FACILITY MANAGEMENT SYSTEM

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 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 the same manufacturer that is providing the VAV air handling units. The supplied system shall meet all of the requirements of this specification.

1.5 SUBMITTALS

A. Within thirty (30) days of contract award, submit 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 **16** 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.

1.12 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.

1.13 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.

1.14 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.

1.15 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.

1.16 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.

1.17 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.

1.18 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 wired 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 wired 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.

1.19 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.

1.20 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.

1.21 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.

1.22 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.

1.23 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.

1.24 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.

1.25 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.

1.26 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.

1.27 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.

1.28 LIQUID DIFFERENTIAL PRESSURE SWITCH

A. Switch shall have an adjustable setpoint of from 0 to 150 psig and a minimum differential of 1 psig. One snap acting SPDT switch enclosed under a NEMA 4 enclosure with 1/2" conduit opening and rated for 5 amps at 120 VAC shall be provided. Kele & Associates Model 24-013 or equivalent.

1.29 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.

1.30 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.

1.31 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.

1.32 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.

1.33 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.

D. Control Butterfly Valves

1. Valve body shall be of the full lug-wafer style, drilled and tapped for isolation and removal of downstream piping. Flanges shall meet ANSI 125 and 150 standards. The body shall feature an extended neck allowing for sufficient clearance for flanges and piping insulation. The cast-in top plate shall allow for direct mounting of all actuators.
2. The disc and hub edge shall be rounded and hand polished to a 32 AARH or better finish to protect seats from damage and to reduce frictional torque. The disc shall have a full 360 degree concentric seating, minimum flow restriction and self-locking stainless steel disc to stem screws for quick and easy disassembly. A torque plug shall provide a positive leak-proof connection of the disc to the stem.
3. Valves shall feature a single, through-shaft design for high strength and positive disc control.
4. The seat shall be heavy duty with molded-in O-rings creating a positive seal between flange face and valve body. No gaskets shall be required between the valve and flange faces. The resilient seat shall provide a bubble-tight shutoff in either direction with the disc closed. Seat design shall isolate the body and stem from the flowing media. The seat shall not be bonded to the valve body and shall be easily replaceable in the field.
5. The primary steam seals shall be formed by preloaded contact of the disc hub with flatted seat surfaces. The secondary stem seal shall be formed by an engineered interference fit (stem diameter larger than stem passage hole) of the stem through the seat. An internal bi-directional stem seal, located in the upper journal, shall be self-adjusting and support full vacuum and pressure to prevent contamination of the stem area and act as a tertiary seal to line pressure.
6. The top bushing, located in the upper journal, shall be non-corrosive and heavy duty to absorb actuator side thrust. Upper and lower non-wetted, metal inboard stem bearings shall be isolated from the flow media.
7. All valves are factory tested to 10 percent of specified pressure rating. The lugged version is rated for 50 psi dead-end service for removal of downstream piping.
8. Belimo, Bray, or equivalent.

1.34 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.

B. Electronic Butterfly Valve Actuators

1. Actuators shall have a single phase permanent split-capacitor reversible motor with 120 VAC power. The motor shall contain a built-in UL approved automatic reset thermal overload protector embedded in the motor windings. Actuators shall be designed for butterfly valves or ball valves. Use of modified damper type actuators shall not be accepted.
2. All travel switches shall be single pole, double throw, form C type rated for 10 A at 125 VAC. Travel limit switches shall limit the actuator in both the open and closed position.
3. Mechanical stainless steel travel stops shall be located outside the actuator for ease of adjustment and contain stainless steel lock nuts to hold the travel stops in place.
4. All units shall be equipped with an aluminum manual override hand wheel to rotate the valve without electrical power and disengage power if power is still applied to the valve. The override assembly shall ensure positive and fast manual operating without the use of extra tools.
5. The actuator enclosure shall be certified to UL, CSA, & CE waterproof standards NEMA 4.
6. Modulating actuators shall be positive positioning, responding to a 4-20 mA or 0-10VDC signal with a modulating 4-20 mA output from the valve indicating actual valve position.
7. Provide open and closed end switches for status feedback on all two-position valves.

8. The actuators and valves shall be factory mounted and tested and supplied. Belimo, Bray, or equivalent.

1.35 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.

1.36 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.

1.37 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.

1.38 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.

1.39 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.

1.40 EQUIPMENT CONNECTIONS

A. Not Applicable.

1.41 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.

1.42 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.

1.43 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.

1.44 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.

1.45 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.

1.46 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.

1.47 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.

1.48 PRIMARY OPERATORS STATIONS

A. The new primary operator workstation/ server 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.

1.49 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. In 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.

1.50 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.

1.51 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.

1.52 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.

1.53 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.

1.54 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.

1.55 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.

1.56 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.

1.57 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.

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.

1.58 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.

1.59 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.

C. Space humidity transmitters shall be installed at the same height as space temperature sensors.

1.60 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.

1.61 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.

1.62 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.

1.63 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.

1.64 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.

1.65 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.

1.66 AUTOMATIC DAMPERS

A. All automatic control dampers shall be installed under Section 23 3000.

1.67 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.

1.68 CONTROL VALVES

A. The valves shall be installed by the mechanical contractor under other Sections of the Specification.

1.69 CONTROL VALVE ACTUATORS

A. Electronic Valve Actuators

1. Valve actuators shall be supplied factory assembled with the respective control valve.

1.70 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.

1.71 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.

1.72 SMOKE AND FIRE DETECTORS

A. Smoke detectors and the associated wiring shall be installed in accordance with Section 23 0549.

1.73 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.

1.74 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 same height as space temperature sensors.

1.75 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.

1.76 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.

1.77 INDOOR STATIC AIR PROBE

A. Indoor static air probes shall be mounted in the ceiling in locations indicated on the Drawings or as required.

1.78 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.

1.79 ELECTRONIC HVAC LIQUID FLOWMETER

A. The flow meter/transmitter shall be installed according to the manufacturer's recommendations and tied into the FMS system.

1.80 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.

1.81 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 230900

APPENDIX A

Verification Trend Log Development and Acceptance Requirements

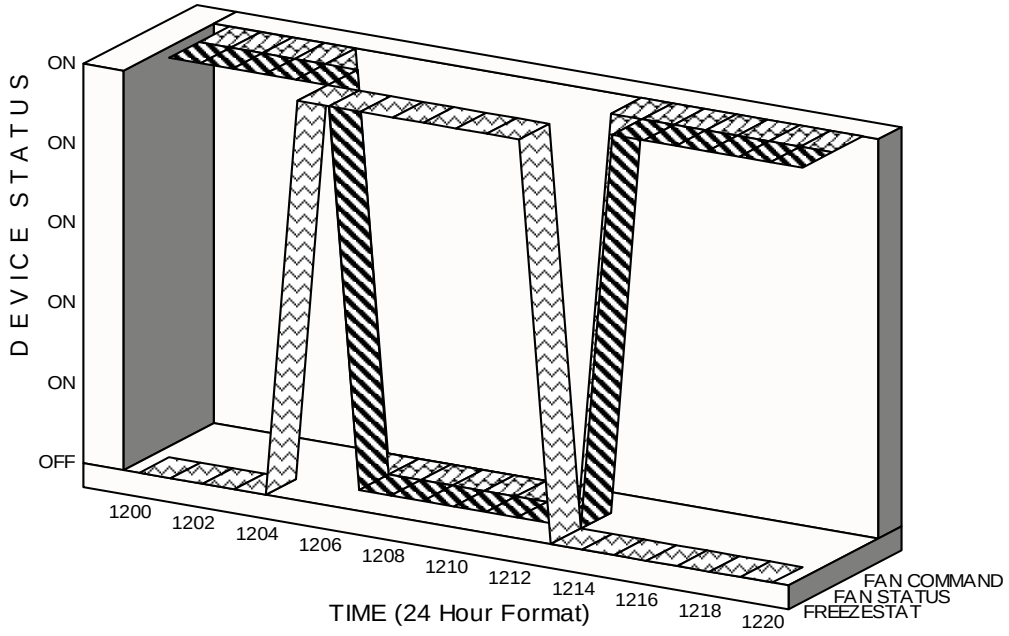
AHU-1 TREND LOG REQUIREMENTS			
Trend #1 (Supply Air Temperature Control)			
Trend Duration	Sample Interval	Trend Points	Required Response
60 minutes during occupied mode	1 minute	SA temperature SA temperature set point DX control signal Furnace signal	SA temperature ±0.5°F of SA temperature SP with 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 Freeze 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.

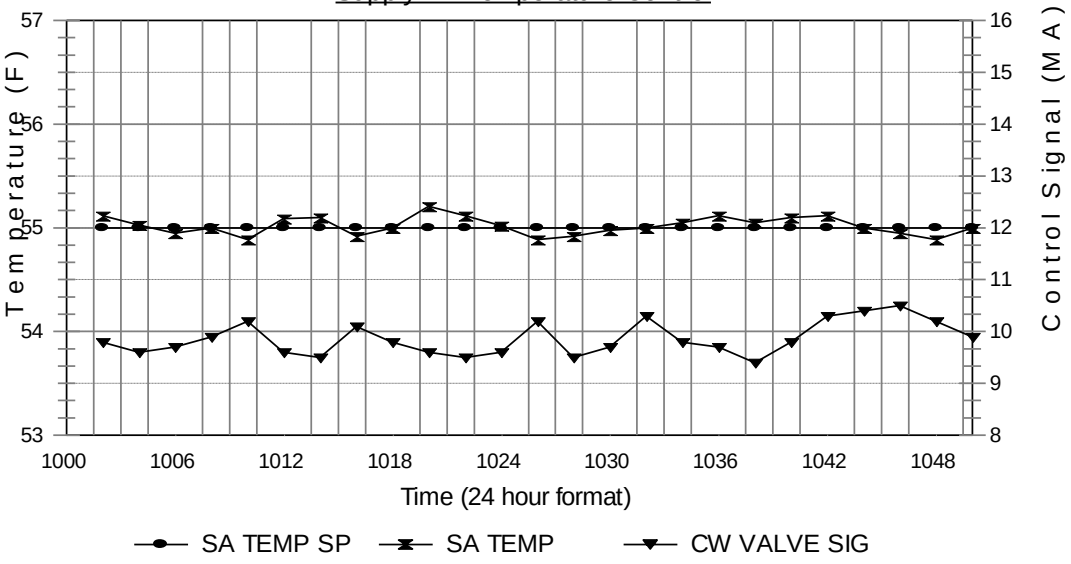
SECONDARY HOTWATER SYSTEM TREND LOG REQUIREMENTS			
Trend #1 (Differential Pressure Control)			
Trend Duration	Sample Interval	Trend Points	Required Response
60 minutes	1 minute	HW differential pressure HW differential pressure set point Control signal to VFD #1 Control signal to VFD #2	Differential 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 CW 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 232313 - REFRIGERANT PIPING SYSTEM AND EQUIPMENT

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.

1.3 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. All refrigerants recovered from all systems shall be disposed of in compliance with these same regulations.

1.4 FAN COIL UNITS

A. Fan Coil Units shall be as specified on the Equipment Schedule on the drawings and Section 23 3000.

1.5 AIR COOLED CONDENSER

A. Furnish and install air cooled condensers located on building roof as shown on the drawings. Air cooled condenser shall be of type and capacity as specified in the Mechanical Equipment Schedule on the drawings.

1.6 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. The piping is shown schematically on the drawings, verify exact arrangement and pipe sizing with equipment manufacturer.

1.7 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.

1.8 DRYER

A. In each liquid line, install a suitable silica gel filter and dryer. Dryer shall be furnished with the chiller.

1.9 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.

1.10 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 450 lbs. per square inch using dry nitrogen.

1.11 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.

1.12 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.

1.13 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 232313

SECTION 233000 - AIR TEMPERING SYSTEM AND EQUIPMENT

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, 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 2012 Chapter 6 – Duct Systems
2. SMACNA 2006 HVAC Duct Construction Standards – Metal and Flexible, 3rd edition
3. SMACNA Round Industrial Duct Construction Standards – 2005
4. SMACNA Rectangular Industrial Duct Construction Standards – 2005
5. NFPA-90A-2015 - 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 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.

1.7 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/A653-03 Standard Specification for Steel Sheet, Zinc-Coat (Galvanized) or Zinc-Iron Alloy-Coat (Galvanized) by the Hot Dip Process, with minimum 1.25oz/sf zinc.
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 +250°F. 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 +200°F 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 40–110°F. 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.

1.8 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 24-inch high (unless noted otherwise), 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: See Mechanical Equipment Schedules.

G. Thermometers: As specified in Section 23 0505.

H. 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.

1.9 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.
    c. 12-year warranty against defects in materials and workmanship

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 550° 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.

4. Metal Fab Type CG

1.10 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, 350ºF, 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 165º F. Where indicated provide thermal links for operation at 212º F, 250º F, or 350º 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 350º 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.

1.11 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, filters shall be MERV-8 AAF, Camfil Farr, or approved equal.

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.

1.12 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° 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° deflection, flange for surface mounting, and SS 90° 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° 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.

1.13 FANS

A. General

1. Construction

a. Factory fabricated fan, motor, drive and accessories, UL listed , 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 24-inch (unless noted otherwise) 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.

1.14 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.

1.15 MAKE-UP AIR UNITS

A. General
   1. Outdoor unit with double wall construction and 1 inch fiberglass insulation. Bas insulation shall also be 1” fiberglass. Unit shall be G90 galvanized steel with hinged access doors.

B. Supply Fan
   1. Forward curved supply fan shall be belt drive and the variable frequency drive shall be factory provided.
   2. Supply fan and motor shall have neoprene vibration isolation.

C. Evaporative Cooling
   1. Evaporative cooling section shall have a stainless steel sump and media casing.
   2. Factory provided solenoid valves for supply, drain and supply line drain (winterization) shall be provided.
   3. Recirculating pump and auto drain and fill shall be factor provided.

D. Gas heat
   1. Direct gas heat shall have 92% thermal efficiency and have electronic modulation burner control with an electronic modulating valve.
   2. Cast aluminum burner manifold with stainless steel mixing plates.

E. Controls
   1. Provide factory microprocessor controller and BMS communication card.
   2. Provide dirty filter switch, heating and cooling inlet air sensors and supply air low limit for freeze protection.

1.16 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 2012 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 Single Zone AHU to Diffuser	P	2”
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 includ 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. 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. Refer to Specification 23 0548 Vibration and Seismic Control for HVAC. Ductwork Associated with equipment have a Seismic Importance Factor IP=1.5 shall comply with this Seismic Bracing requirements.
2. 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.
3. Hangers for terminal units: Minimum four 1" x 1/8" galvanized steel straps or two angle trapeze supports.
4. 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.

1.17 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.

1.18 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.

1.19 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.

1.20 FILTERS AND FILTER GAUGES

A. Provide one set of MERV-7 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.

1.21 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.

1.22 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 233000

SECTION 260500 - COMMON WORK RESULTS FOR ELECTRICAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General Conditions, Supplementary 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. See Section 23 0549 – Mechanical/Electrical Installation Coordination.

D. See Division 2, Site Work for Trenching, Backfilling and Compaction requirements.

E. See Division 1, Coordination for additional requirements.

F. See Division 1, Submittals for additional requirements.

G. See Division 7, Joint Sealants for additional 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

1.3 CODES AND PERMITS

A. Perform electrical work in strict accordance with the applicable provisions of the National Electrical Code, Latest Edition; National Electric Safety Code, Latest Edition; the International Building Code, Latest Edition as adopted and interpreted by the State of New Mexico, City of Gallup, 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.

Applicable county and state electrical codes, laws and ordinances.

National Electrical Manufacturer's Association Standards

National Electrical Code

National Electrical Safety 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

Institute of Electrical and Electronics Engineers Standards

Insulated Cable Engineers Association

Occupational Safety and Health Act

International Fire Code

Americans with Disabilities Act

Commercial and Industrial Insulation Standards (MICA)

1.4 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 Construction Manager 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 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, Section "PROJECT CLOSEOUT." In addition to the requirements specified in Division 1, indicate installed conditions for:

1. All raceway systems including manholes, size and location (vertical & horizontal). Survey all conduit runs prior to backfill.
2. Equipment pad locations, dimensioned from prominent building lines and centers of conduit stub-ups.
3. Approved substitutions, Contract Modifications, and actual equipment and materials installed.

1.5 QUALIFICATIONS

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

1.6 SUBSTITUTIONS

A. 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.

B. 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.

1.7 PRIOR APPROVAL

A. 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.

1.8 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.

1.9 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.

1.10 SUBMITTALS

A. The Contractor shall submit submittal brochures of equipment, fixtures and materials to be furnished under Division 26.

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. Costs for the preparation, correction, delivery, and return of the submittals shall be borne by the Contractor.

E. Complete data must be furnished showing performance, quality and dimensions. No equipment or materials shall be purchased prior to receiving written notification from the Architect/Engineer 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 to the Architect/Engineer.

F. 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 a minimum of 3 feet clear in front of all electrical equipment and panels as defined by the National Electrical Code. 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.

G. 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, 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.

H. 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.

I. 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 Engineer with the shop drawing submittals of the substituted. Failure to comply with this requirement will result in the shop drawings being returned unchecked.

J. 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.

K. See Division 1 for additional submission requirements.

L. The Contractor shall submit a maximum amount of seven (7) copies of submittal brochures for review. Brochures shall be submitted within thirty (30) days after contract award. One (1) copy of all submittals will be retained by the Engineer, with the remaining six (6) sets returned to the Owner's Representative. Additional sets of submittals, if required by the Contractor, shall be reproduced by the Contractor from the reviewed and marked sets returned to the Contractor.

1.11 MAINTENANCE MANUALS

A. Prepare maintenance manuals in accordance with Division 1, Section "PROJECT CLOSEOUT." 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.

1.12 COORDINATION DRAWINGS

A. Prepare coordination drawings in accordance with Division 1, Section "PROJECT COORDINATION", 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, light fixtures, communications systems components, sprinklers, and other ceiling-mounted devices.

1.13 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.

1.14 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 Owner's Representative.

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 Owner's Representative shall interpret the drawings and the specifications. The Owner's Representative'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 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.

1.15 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.

1.16 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.

1.17 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 two (2) year parts and labor warranty.

1.18 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.

1.19 ALTITUDE RATINGS

A. Unless otherwise noted, all specified equipment capacities are for an altitude of 5,200 feet above sea level and adjustments to manufacturer's ratings must be made accordingly.

1.20 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.

1.21 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.

1.22 DRAWINGS

A. The electrical drawings show the general arrangement of equipment, conduit runs, 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 installation of all concealed electrical systems shall be carefully arranged to fit within the available space without interference with adjacent structural and mechanical systems.

1.23 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 utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.
8. 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 Owner's Representative.
9. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components.

10. 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.
11. Install systems, materials, and equipment giving right-of-way priority to systems requiring installation at a specified slope.

1.24 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.

1.25 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 Owner’s Representative that the devices and supports are adequate as intended and do not overload the building's structural components in any way.

1.26 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 Engineer.

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 Construction Manager 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, fixtures, equipment and materials shall be cleaned and polished thoroughly and delivered in a condition satisfactory to the Engineer.

1.27 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.

1.28 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."

1.29 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.

1.30 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.

1.31 CUTTING AND PATCHING

A. Perform cutting and patching in accordance with Division 1, Section "CUTTING AND PATCHING." 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. Provide and maintain temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to adjacent areas.
3. During cutting and patching operations, protect adjacent installations.
4. Patch existing finished surfaces and building components using new materials matching existing materials and experienced installers.

1.32 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 Engineer who shall make such compromises as he deems necessary and desirable.

1.33 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.

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.

1.34 TESTS

A. All tests shall be conducted in the presence of the designated and authorized Owner's Representative. The Contractor shall notify the Construction Manager two weeks in advance of all tests. The Contractor shall furnish all necessary equipment, materials, and labor to perform the required tests.

1.35 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 five (5) 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 record the instruction and training sessions using a DVD camcorder, and at the completion and acceptance (by Owner and Architect) of the training sessions, the Contractor shall submit (2) copies of the DVD.

1.36 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 Owner’s Representative including proof of delivery of O&M manuals, spare parts required, and equipment warranties which shall be bound with O&M manuals.

1.37 OPERATION PRIOR TO ACCEPTANCE

A. Operation of equipment and systems installed by the Contractor for the benefit of the Owner prior to substantial completion will be allowed providing 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 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 and the Contractor establishing warranty and other responsibilities.

1.38 SITE VISITS AND OBSERVATION OF CONSTRUCTION

A. The Owner’s Representative/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 260500

SECTION 260513 - MEDIUM-VOLTAGE CABLES

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 cables and related cable splices, terminations, and accessories for medium-voltage (2001 to 35,000 V) electrical distribution systems.

1.3 DEFINITIONS

A. Jacket: A continuous nonmetallic outer covering for conductors or cables.

B. NETA ATS: Acceptance Testing Specification.

C. Sheath: A continuous metallic covering for conductors or cables.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of cable. Include splices and terminations for cables and cable accessories.

B. Samples: 16-inch (400-mm) lengths for each type of cable specified.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Indicate location of each cable, splice, and termination.

B. Qualification Data: For Installer and testing agency.

C. Material Certificates: For each type of cable and accessory.

D. Design Data: Cable pulling calculations, including conduit size and fill percentage, pulling tensions, cable sidewall pressure, jam probability, voltage drop, and ground wire sizing for each cable.

E. Source quality-control reports.

F. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Installer: Engage a cable splicer, trained and certified by splice material manufacturer, to install, splice, and terminate medium-voltage cable.

B. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.7 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 IEEE C2 and NFPA 70.

C. Source Limitations: Obtain cables and accessories from single source from single manufacturer.

1.8 CABLES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. General Cable; General Cable Corporation.
2. Okonite Company (The).
3. Southwire Company.
4. Superior Essex Inc.

B. Cable Type: Type MV 105.

C. Conductor Insulation: Ethylene-propylene rubber.

1. Voltage Rating: 15 kV.
2. Insulation Thickness: 133 percent insulation level.

D. Conductor: Copper.

E. Comply with UL 1072, AEIC CS8[, ICEA S-93-639/NEMA WC 74, and ICEA S-97-682.

F. Conductor Stranding: Compact round, concentric lay, Class B.

G. Strand Filling: Conductor interstices are filled with impermeable compound.

H. Shielding: Copper tape, helically applied over semiconducting insulation shield.

1. Circuit Identification: Color-coded tape (black, red, blue) under the metallic shielding.

I. Cable Jacket: Sunlight-resistant PVC.

1.9 CONNECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. 3M.
2. Cooper Power Systems, an Eaton business.
3. Raychem; TE Connectivity.
4. Thomas & Betts Corporation; A Member of the ABB Group.

B. Copper-Conductor Connectors: Copper barrel crimped connectors.

1.10 SOLID TERMINATIONS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. 3M.
2. Cooper Power Systems, an Eaton business.
3. Raychem; TE Connectivity.
4. Thomas & Betts Corporation; A Member of the ABB Group.

B. Shielded-Cable Terminations: Comply with the following classes of IEEE 48. Insulation class shall be equivalent to that of cable. Include shield ground strap for shielded cable terminations.

1. Class 1 Terminations: Modular type, furnished as a kit, with stress-relief tube; multiple, molded-silicone-rubber, insulator modules; shield ground strap; and compression-type connector.
2. Class 2 Terminations, Indoors: Kit with stress-relief tube, nontracking insulator tube, shield ground strap, and compression-type connector. Include silicone-rubber tape; cold-shrink-rubber sleeve; or heat-shrink, plastic-sleeve moisture seal for end of insulation whether or not supplied with kits.

1.11 SEPARABLE INSULATED CONNECTORS

A. Description: Modular system, complying with IEEE 386, with disconnecting, single-pole, cable terminators and with matching, stationary, plug-in, dead-front terminals designed for cable voltage and for sealing against moisture.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Cooper Power Systems, an Eaton business.
2. Raychem; TE Connectivity.
3. Thomas & Betts Corporation; A Member of the ABB Group.

C. Terminations at Distribution Points: Modular type, consisting of terminators installed on cables and modular, dead-front, terminal junctions for interconnecting cables.

D. Load-Break Cable Terminators: Elbow-type units with 200-A-load make/break and continuous-current rating; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.

E. Dead-Break Cable Terminators: Elbow-type unit with 600-A continuous-current rating; designed for de-energized disconnecting and connecting; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.

F. Dead-Front Terminal Junctions: Modular bracket-mounted groups of dead-front stationary terminals that mate and match with above cable terminators. Two-, three-, or four-terminal units as indicated, with fully rated, insulated, watertight conductor connection between terminals and complete with grounding lug, manufacturer's standard accessory stands, stainless-steel mounting brackets, and attaching hardware.

1. Protective Cap: Insulating, electrostatic-shielding, water-sealing cap with drain wire.
2. Portable Feed-Through Accessory: Two-terminal, dead-front junction arranged for removable mounting on accessory stand of stationary terminal junction.
3. Grounding Kit: Jumpered elbows, portable feed-through accessory units, protective caps, test rods suitable for concurrently grounding three phases of feeders, and carrying case.
4. Standoff Insulator: Portable, single dead-front terminal for removable mounting on accessory stand of stationary terminal junction. Insulators suitable for fully insulated isolation of energized cable-elbow terminator.

1.12 SPLICE KITS

A. Description: For connecting medium voltage cables; type as recommended by cable or splicing kit manufacturer for the application.

B. 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. Cooper Power Systems, an Eaton business.
2. Raychem; TE Connectivity.
3. Thomas & Betts Corporation; A Member of the ABB Group.

C. Standard: Comply with IEEE 404.

D. Splicing Products: As recommended, in writing, by splicing kit manufacturer for specific sizes, materials, ratings, and configurations of cable conductors. Include all components required for complete splice, with detailed instructions.

1. Premolded, cold-shrink-rubber, in-line splicing kit.

1.13 MEDIUM-VOLTAGE TAPES

A. Description: Electrical grade, insulating tape rated for medium voltage application.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. 3M.
2. Cooper Power Systems, an Eaton business.
3. Raychem; TE Connectivity.
4. Thomas & Betts Corporation; A Member of the ABB Group.

C. Ethylene/propylene rubber-based, 30-mil (0.76-mm) splicing tape, rated for 130 deg C operation. Minimum 3/4 inch (20 mm) wide.

1.14 ARC-PROOFING MATERIALS

A. Description: Fire retardant, providing arc flash protection.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. 3M.
2. Cooper Power Systems, an Eaton business.
3. Raychem; TE Connectivity.
4. Thomas & Betts Corporation; A Member of the ABB Group.

C. Tape for First Course on Metal Objects: 10-mil- (250-micrometer-) thick, corrosion-protective, moisture-resistant, PVC pipe-wrapping tape.

D. Arc-Proofing Tape: Fireproof tape, flexible, conformable, intumescent to 0.3 inch (8 mm) thick, and compatible with cable jacket.

E. Glass-Cloth Tape: Pressure-sensitive adhesive type, 1 inch (25 mm) wide.

1.15 SOURCE QUALITY CONTROL

A. Test and inspect cables according to ICEA S-97-682 before shipping.

1.16 INSTALLATION

A. Install cables according to IEEE 576.

B. Proof conduits prior to conductor installation by passing a wire brush mandrel and then a rubber duct swab through the conduit. Separate the wire brush and the rubber swab by 48 to 72 inches (1200 to 1800 mm) on the pull rope.

1. Wire Brush Mandrel: Consists of a length of brush approximately the size of the conduit inner diameter with stiff steel bristles and an eye on each end for

attaching the pull ropes. If an obstruction is felt, pull the brush back and forth repeatedly to break up the obstruction.

2. Rubber Duct Swab: Consists of a series of rubber discs approximately the size of the conduit inner diameter on a length of steel cable with an eye on each end for attaching the pull ropes. Pull the rubber duct swab through the duct to extract loose debris from the duct.

C. Pull Conductors: Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

1. Where necessary, use manufacturer-approved pulling compound or lubricant that does not deteriorate conductor or insulation.
2. Use pulling means, including fish tape, cable, rope, and basket-weave cable grips, that do not damage cables and raceways. Do not use rope hitches for pulling attachment to cable.
3. Use pull-in guides, cable feeders, and draw-in protectors as required to protect cables during installation.
4. Do not pull cables with ends unsealed. Seal cable ends with rubber tape.

D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.

E. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."

F. Install direct-buried cables on leveled and tamped bed of 3-inch- (75-mm-) thick, clean sand. Separate cables crossing other cables or piping by a minimum of 2 inches (50 mm) of tamped earth, plus an additional 2 inches (50 mm) of sand. Install permanent markers at ends of cable runs, changes in direction, and buried splices.

G. Install "buried-cable" warning tape 12 inches (305 mm) above cables.

H. In manholes, handholes, pull boxes, junction boxes, and cable vaults, train cables around walls by the longest route from entry to exit; support cables at intervals adequate to prevent sag.

I. Install sufficient cable length to remove cable ends under pulling grips. Remove length of conductor damaged during pulling.

J. Install cable splices at pull points and elsewhere as indicated; use standard kits. Use dead-front separable watertight connectors in manholes and other locations subject to water infiltration.

K. Install terminations at ends of conductors, and seal multiconductor cable ends with standard kits.

L. Install separable insulated-connector components as follows:

1. Protective Cap: At each terminal junction, with one on each terminal to which no feeder is indicated to be connected.

2. Portable Feed-Through Accessory: At each terminal junction, with one on each terminal.
3. Standoff Insulator: At each terminal junction, with one on each terminal.

M. Arc Proofing: Unless otherwise indicated, arc proof medium-voltage cable at locations not protected by conduit, cable tray, direct burial, or termination materials. In addition to arc-proofing tape manufacturer's written instructions, apply arc proofing as follows:

1. Clean cable sheath.
2. Wrap metallic cable components with 10-mil (250-micrometer) pipe-wrapping tape.
3. Smooth surface contours with electrical insulation putty.
4. Apply arc-proofing tape in one half-lapped layer with coated side toward cable.
5. Band arc-proofing tape with two layers of 1-inch- (25-mm-) wide half-lapped, adhesive, glass-cloth tape at each end of the arc-proof tape.

N. Seal around cables passing through fire-rated elements according to Section 078413 "Penetration Firestopping."

O. Install fault indicators on each phase where indicated.

P. Ground shields of shielded cable at terminations, splices, and separable insulated connectors. Ground metal bodies of terminators, splices, cable and separable insulated-connector fittings, and hardware.

Q. Ground shields of shielded cable at one point only. Maintain shield continuity and connections to metal connection hardware at all connection points.

R. Identify cables according to Section 260553 "Identification for Electrical Systems." Identify phase and circuit number of each conductor at each splice, termination, pull point, and junction box. Arrange identification so that it is unnecessary to move the cable or conductor to read the identification.

1.17 FIELD QUALITY CONTROL

A. Testing Agency: Owner will 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 each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.
2. After installing medium-voltage cables and before electrical circuitry has been energized, test for compliance with requirements.

3. Perform direct-current High Potential test of each new conductor according to NETA ATS, Ch. 7.3.3. Do not exceed cable manufacturer's recommended maximum test voltage.
4. Perform Partial Discharge test of each new conductor according to NETA ATS, Ch. 7.3.3 and to test equipment manufacturer's recommendations.
5. Perform Dissipation Factor test of each new conductor according to NETA ATS, Ch. 7.3.3 and to test equipment manufacturer's recommendations.

D. Medium-voltage cables will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

END OF SECTION 260513

SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

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. Copper building wire rated 600 V or less.
2. Connectors, splices, and terminations rated 600 V and less.

B. Related Requirements:

1. Section 260513 "Medium-Voltage Cables" for single-conductor, cable splices, and terminations for electrical distribution systems with 601 to 35,000 V.

1.3 DEFINITIONS

A. RoHS: Restriction of Hazardous Substances.

B. VFC: Variable-frequency controller.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Product Schedule: Indicate type, use, location, and termination locations.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.7 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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Okonite Company (The).
2. 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. RoHS compliant.
3. 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 for stranded conductors.

E. Conductor Insulation:

1. Type THHN and Type THWN-2: Comply with UL 83.
2. Type XHHW-2: Comply with UL 44.

1.8 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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. 3M Electrical Products.
2. ILSCO.

3. Thomas & Betts Corporation; A Member of the ABB Group.

C. 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.

1.9 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper; solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

C. VFC Output Circuits Cable: Extra-flexible stranded for all sizes.

D. Power-Limited Fire Alarm and Control: Solid for No. 12 AWG and smaller.

1.10 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type THHN/THWN-2, single conductors in raceway.

B. Exposed Feeders: Type THHN/THWN-2, single conductors in raceway.

C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN/THWN-2, single conductors in raceway.

D. Feeders below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway.

E. Feeders Installed below Raised Flooring: Type THHN/THWN-2, single conductors in raceway.

F. Exposed Branch Circuits, Including in Crawlspaces: Type THHN/THWN-2, single conductors in raceway.

G. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single conductors in raceway.

H. Branch Circuits below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway.

I. Branch Circuits Installed below Raised Flooring: Type THHN/THWN-2, single conductors in raceway.

J. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

K. VFC Output Circuits: Type XHHW-2 in metal conduit.

1.11 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and below floors unless otherwise indicated.

B. Complete raceway installation between conductor and cable termination points according to Section 260533 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.

C. 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.

D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

F. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."

1.12 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 6 inches (150 mm) of slack.

1.13 IDENTIFICATION

A. Identify and color-code conductors and cables according to Section 260553 "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.

1.14 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."

1.15 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 078413 "Penetration Firestopping."

1.16 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors feeding the following critical equipment and services for compliance with requirements:
2. 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.

C. Cables will be considered defective if they do not pass tests and inspections.

D. 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 260519

SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

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, plus the following special applications:

1. Underground distribution grounding.
2. Ground bonding common with lightning protection system.
3. 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 017823 "Operation and Maintenance Data," 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) Ground rings.
4) 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 based on NETA MTS.

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: Certified by NETA.

1.7 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.

1.8 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Burndy; Part of Hubbell Electrical Systems.
2. ERICO International Corporation.
3. Harger Lightning & Grounding.
4. ILSCO.
5. O-Z/Gedney; a brand of Emerson Industrial Automation.
6. Robbins Lightning, Inc.
7. Thomas & Betts Corporation; A Member of the ABB Group.

1.9 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. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
4. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
5. Bonding Jumper: 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.

1.10 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 or exothermic-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 one-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 zinc-plated bolts.

a. Material: Tin-plated aluminum.
b. Listed for direct burial.

2. U-bolt type with malleable-iron clamp and copper ground connector.

1.11 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad; 3/4 inch by 10 feet.

B. Ground Plates: 1/4 inch thick, hot-dip galvanized.

1.12 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. 4/0 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.

1.13 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.

1.14 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.

1.15 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.

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, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields according to written instructions by manufacturer of splicing and termination kits.

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.

1.16 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders and branch circuits.

B. 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.

C. 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.

D. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

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. 1/0 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.

1.17 FENCE GROUNDING

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 at openings indicated as intentional fence discontinuities. Use No. 2 AWG wire and bury it at least 18 inches below finished grade.

B. Fences Enclosing Electrical Power Distribution Equipment: Ground as required by IEEE C2 unless otherwise indicated.

C. 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 grounding location.

D. Bonding Method for Gates: Connect bonding jumper between gate post and gate frame.

E. 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.

1.18 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 100 feet apart.

I. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each steel column and indicated item, extending around the perimeter of building.

1. Install tinned-copper conductor not less than No. 4/0 AWG for ground ring and for taps to building steel.
2. Bury ground ring not less than 24 inches from building's foundation.

J. Concrete-Encased Grounding Electrode (Ufer Ground): Fabricate according to NFPA 70; use a minimum of 20 feet of bare copper conductor not smaller than No. 4/0 AWG.

1. If concrete foundation is less than 20 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.

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.

1.19 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Tests and Inspections:

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. 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 ohm(s).
5. Substations and Pad-Mounted Equipment: 5 ohms.
6. Manhole Grounds: 10 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 260526

SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

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. Section 260548.16 "Seismic Controls for Electrical Systems" 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: 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.

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.

1.6 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.

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: 1.5.
3. Insert requirements for Component Amplification Factor and Component Response Modification Factor.

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.

1.7 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 in at least one surface.

1. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
2. Material for Channel, Fittings, and Accessories: Galvanized steel.
3. Channel Width: Selected for applicable load criteria.
4. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
5. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
6. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
7. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

B. Aluminum Slotted Support Systems: Extruded-aluminum channels and angles with minimum 13/32-inch- diameter holes at a maximum of 8 inches o.c. in at least one surface.

1. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.

2. Channel Material: 6063-T5 aluminum alloy.
3. Fittings and Accessories Material: 5052-H32 aluminum alloy.
4. Channel Width: Selected for applicable load criteria 1-5/8 inches.
5. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
6. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
7. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

C. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

D. 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.

E. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M steel plates, shapes, and bars; black and galvanized.

F. 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.
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.
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.

1.8 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 055000 "Metal Fabrications" for steel shapes and plates.

1.9 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 078413 "Penetration 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 260533 "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 required by 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 or other 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 two-bolt conduit clamps.

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.

1.10 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, IMC and RMC 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.
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.

1.11 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Section 055000 "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.

1.12 CONCRETE BASES

A. Construct concrete bases of dimensions indicated, but not less than 4 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 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.

1.13 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 099113 "Exterior Painting", Section 099123 "Interior Painting" and Section 099600 "High-Performance Coatings" 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 260529

SECTION 260533 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

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 for exterior underground wiring.

B. Related Requirements:

1. Section 078413 "Penetration Firestopping" for firestopping at conduit and box entrances.
2. Section 260543 "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks, manholes, and underground utility construction.
3. Section 270528 "Pathways for Communications Systems" for conduits, wireways, surface pathways, innerduct, boxes, faceplate adapters, enclosures, cabinets, and handholes serving communications systems.

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. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

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. 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.

C. Source quality-control reports.

1.6 METAL CONDUITS AND FITTINGS

A. Metal Conduit:

1. Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. GRC: Comply with ANSI C80.1 and UL 6.
3. ARC: Comply with ANSI C80.5 and UL 6A.
4. IMC: Comply with ANSI C80.6 and UL 1242.
5. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit.
    a. Comply with NEMA RN 1.
    b. Coating Thickness: 0.040 inch (1 mm), minimum.
6. EMT: Comply with ANSI C80.3 and UL 797.
7. FMC: Comply with UL 1; zinc-coated steel.
8. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.

B. Metal Fittings:

1. Comply with NEMA FB 1 and UL 514B.
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. Fittings, General: Listed and labeled for type of conduit, location, and use.
4. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 1203 and NFPA 70.

5. Fittings for EMT:
    a. Material: Steel.
    b. Type: compression.
6. 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.
7. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch (1 mm), 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.

1.7 NONMETALLIC CONDUITS AND FITTINGS

A. Nonmetallic Conduit:

1. 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.
2. ENT: Comply with NEMA TC 13 and UL 1653.
3. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.
4. LFNC: Comply with UL 1660.

B. Nonmetallic Fittings:

1. Fittings, General: Listed and labeled for type of conduit, location, and use.
2. 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.
3. Solvents and Adhesives: As recommended by conduit manufacturer.

1.8 METAL WIREWAYS AND AUXILIARY GUTTERS

A. Description: Sheet metal, complying with UL 870 and NEMA 250, 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.

B. 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.

C. Wireway Covers: Hinged type unless otherwise indicated.

D. Finish: Manufacturer's standard enamel finish.

1.9 NONMETALLIC WIREWAYS AND AUXILIARY GUTTERS

A. Listing and Labeling: Nonmetallic wireways and auxiliary gutters shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Description: Fiberglass polyester, extruded and fabricated to required size and shape, without holes or knockouts. Cover shall be gasketed with oil-resistant gasket material and fastened with captive screws treated for corrosion resistance. Connections shall be flanged and have stainless-steel screws and oil-resistant gaskets.

C. Description: PVC, extruded and fabricated to required size and shape, and having snap-on cover, mechanically coupled connections, and plastic fasteners.

D. Fittings and Accessories: Couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings shall match and mate with wireways as required for complete system.

1.10 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.

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.

1.11 BOXES, ENCLOSURES, AND CABINETS

A. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.

B. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

C. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, aluminum, Type FD, with gasketed cover.

D. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.

E. 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.

F. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb (23 kg). Outlet boxes designed for attachment of luminaires weighing more than 50 lb (23 kg) shall be listed and marked for the maximum allowable weight.

G. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

H. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, cast aluminum with gasketed cover.

I. Box extensions used to accommodate new building finishes shall be of same material as recessed box.

J. Device Box Dimensions: 4 inches square by 2-1/8 inches deep (100 mm square by 60 mm deep) Gangable boxes are allowed.

K. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, 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.

L. Cabinets:

1. NEMA 250, 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.

1.12 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. Standard: Comply with SCTE 77.
2. Traffic loading rated.
3. Configuration: Designed for flush burial with integral closed 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".
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 24 Inches Long and Larger: Have inserts for cable racks and pulling-in irons installed before concrete is poured.

1.13 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.

1.14 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below unless otherwise indicated:

1. Exposed Conduit: GRC.
2. Concealed Conduit, Aboveground: GRC.
3. Underground Conduit: RNC, Type EPC-40-PVC concrete encased where indicated.
4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFNC.
5. 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.
3. Exposed and Subject to Severe Physical Damage: GRC. Raceway locations include the following:
    a. Loading dock.

b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
c. Mechanical, electrical rooms and central plant.

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 (21-mm) 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, steel 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 (49 deg C).

1.15 INSTALLATION

A. Slabs on grade or Elevated Slabs: Conduits are NOT ALLOWED to be installed in concrete slabs on grade, OR in elevated slabs.

B. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.

C. 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.

D. Do not install raceways or electrical items on any "explosion-relief" walls or rotating equipment.

E. Do not fasten conduits onto the bottom side of a metal deck roof.

F. Keep raceways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

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 (300 mm) 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, and ceilings unless otherwise indicated. Install conduits parallel or perpendicular to building lines.

L. Support conduit within 12 inches (300 mm) of enclosures to which attached.

M. 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.

N. 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.

O. Coat field-cut threads on PVC-coated raceway with a corrosion-preventing conductive compound prior to assembly.

P. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors including conductors smaller than No. 4 AWG.

Q. 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 (35mm) trade size and insulated throat metal bushings on 1-1/2-inch (41-mm) trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.

R. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.

S. 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.

T. Cut conduit perpendicular to the length. For conduits 2-inch (53-mm) trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.

U. Install pull wires in empty raceways. 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. Cap underground raceways designated as spare above grade alongside raceways in use.

V. Surface Raceways:

1. Install surface raceway with a minimum 2-inch (50-mm) radius control at bend points.
2. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inches (1200 mm) 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.

W. 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.

X. 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.

Y. Comply with manufacturer's written instructions for solvent welding RNC and fittings.

Z. Expansion-Joint Fittings:

1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F (17 deg C) and that has straight-run length that exceeds 25 feet (7.6 m). Install in each run of aboveground RMC and EMT conduit that is located where environmental temperature change may exceed 100 deg F (55 deg C) and that has straight-run length that exceeds 100 feet (30 m).
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 (70 deg C) temperature change.
b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F (86 deg C) temperature change.
c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F (70 deg C) 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 (0.06 mm per meter of length of straight run per deg C) 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 (0.0115 mm per meter of length of straight run per deg C) of temperature change for metal conduits.
4. Install expansion fittings at all locations where conduits cross building or structure expansion joints and in vertical installations to allow for building movement Coordinate with structural engineer.
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.

AA. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72 inches of flexible conduit for recessed and semirecessed 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.

BB. 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 bottom of box unless otherwise indicated.

CC. 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.

DD. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.

EE. Locate boxes so that cover or plate will not span different building finishes.

FF. 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.

GG. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

HH. Set metal floor boxes level and flush with finished floor surface.

II. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

1.16 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 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 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 (75 mm) of concrete for a minimum of 12 inches (300 mm) 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 (1500 mm) from edge of foundation or equipment base. Install insulated grounding bushings on terminations at equipment.
6. Warning Planks: Bury warning planks approximately 12 inches (300 mm) above direct-buried conduits but a minimum of 6 inches (150 mm) below grade. Align planks along centerline of conduit.
7. Underground Warning Tape: Comply with requirements in Section 260553 "Identification for Electrical Systems."

1.17 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

A. Install handholes 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 (12.5-mm) sieve to No. 4 (4.75-mm) 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 (25 mm) above finished grade.

D. Install handholes with bottom below 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.

1.18 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install 0sleeves 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."

1.19 FIRESTOPPING

A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

1.20 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.

1.21 IDENTIFICATION

A. Identify Raceways of Certain Systems with ***Addendum A>** colored banding: Provide colored bands for exposed or accessible raceways of the following systems for identification. **<Addendum A*** Bands shall be pre-tensioned, snap- around colored plastic sleeves, colored adhesive marking tape, or a combination of the two. Make each color band 1 inch wide, completely encircling conduit, and place adjacent bands of two-color markings in contact, side by side. Install bands at changes in direction, at penetrations of walls (both sides) and floors and at 10-foot maximum intervals in straight runs.

1.	Fire Alarm System:	Red
2.	Security Systems:	White
3.	BAS:	Blue and Yellow
4.	120V Control:	Black and White
5.	Computer System:	Dark Blue and White

6. TV Systems: Purple
7. Paging: Brown
8. Telephone: Gray
9. 120/208V Power: Black
10. 277/480V Power: Orange
11. 120/208V Emergency Power: Black and Red
12. 277/480V Emergency Power: Orange and Red
13. Medical Gas: Yellow
14. Nurse Call: Blue
15. Fiber Optic: Gray and Blue

B. Identify junction, pull, and connection boxes: Code-required caution sign for boxes shall be pressure- sensitive, self-adhesive label indicating system voltage in black, preprinted on orange background. Install on outside of box cover. Also label box covers with identity of contained circuits. Use black permanent marker in concealed and pressure-sensitive plastic labels at exposed locations and similar labels. Work must be performed in a craftsman-like manner.

C. Use conductors with color factory-applied the entire length of the conductors except as follows under which conditions field applied color-coding methods may be used in lieu of factory-coded sire for sizes larger than No. 10 AWG:

1. Apply colored, pressure-sensitive plastic tape in half–lapped turns for a distance of 6 inches from terminal points and in pull access points are made. Apply the last two laps of tape with no tension to prevent possible unwinding. Use ¾ inch wide tape in colors as specified. Do not obliterate cable identification markings by taping. Tape locations may be adjusted slightly to prevent such obliteration.

D. Tag or label conductors as follows:

1. Future Connections: Conductors indicated to be for future connection or connection under another contract with identification indicating source and circuit numbers.
2. Multiple Circuits: Where multiple branch circuits are present in the same box the neutral conductor shall be labeled to match corresponding circuit numbers.

END OF SECTION 260533

SECTION 260543 - UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

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. Duct accessories.
4. Precast concrete handholes.
5. Precast manholes.
6. Utility structure accessories.

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 manholes and 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.

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: Qualified according to ASTM E 329 for testing indicated.

1.8 FIELD CONDITIONS

A. Ground Water: Assume ground-water level is 36 inches below ground surface unless a higher water table is noted on Drawings.

1.9 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. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.

1.10 RIGID NONMETALLIC DUCT

A. Underground Plastic Utilities Duct: Type EPC-40-PVCRNC, complying with NEMA TC 2 and UL 651, with matching fittings complying with NEMA TC 3 by same manufacturer as duct.

B. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.

C. Solvents and Adhesives: As recommended by conduit manufacturer.

1.11 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.

B. Underground-Line Warning Tape: Comply with requirements for underground-line warning tape specified in Section 260553 "Identification for Electrical Systems."

1.12 PRECAST CONCRETE HANDHOLES AND BOXES

A. Description: Factory-fabricated, reinforced-concrete, monolithically poured walls and bottom unless open-bottom enclosures are indicated. Frame and cover shall form top of enclosure and shall have load rating consistent with that of handhole or box.

B. Comply with ASTM C 858 for design and manufacturing processes.

C. Frame and Cover: Weatherproof steel frame, with steel cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.

D. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.

E. Cover Legend: Molded lettering, as indicated for each service.

F. Configuration: Units shall be designed for flush burial and have integral closed bottom unless otherwise indicated.

G. Extensions and Slabs: Designed to mate with bottom of enclosure. Same material as enclosure.

1. Extension shall provide increased depth of 12 inches.
2. Slab: Same dimensions as bottom of enclosure, and arranged to provide closure.

H. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.

I. Knockout Panels: Precast openings in walls, arranged to match dimensions and elevations of approaching duct, plus an additional 12 inches vertically and horizontally to accommodate alignment variations.

1. Splayed location.
2. Knockout panels shall be located no less than 6 inches from interior surfaces of walls, floors, or frames and covers of handholes, but close enough to corners to facilitate racking of cables on walls.
3. Knockout panel opening shall have cast-in-place, welded-wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct.
4. Knockout panels shall be framed with at least two additional No. 3 steel reinforcing bars in concrete around each opening.
5. Knockout panels shall be 1-1/2 to 2 inches thick.

J. Duct Entrances in Handhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.

1. Type and size shall match fittings to duct to be terminated.
2. Fittings shall align with elevations of approaching duct and be located near interior corners of handholes to facilitate racking of cable.

K. Handholes 12 inches wide by 24 inches long and larger shall have inserts for cable racks and pulling-in irons installed before concrete is poured.

1.13 PRECAST MANHOLES

A. Description: One-piece units and units with interlocking mating sections, complete with accessories, hardware, and features.

B. Comply with ASTM C 858.

C. Structural Design Loading: Comply with requirements in "Underground Enclosure Application" Article.

D. Knockout Panels: Precast openings in walls, arranged to match dimensions and elevations of approaching duct, plus an additional 12 inches vertically and horizontally to accommodate alignment variations.

1. Splayed location.
2. Knockout panels shall be located no less than 6 inches from interior surfaces of walls, floors, or roofs of manholes, but close enough to corners to facilitate racking of cables on walls.
3. Knockout panel opening shall have cast-in-place, welded-wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct.
4. Knockout panel shall be framed with at least two additional No. 3 steel reinforcing bars in concrete around each opening.
5. Knockout panels shall be 1-1/2 to 2 inches thick.

E. Duct Entrances in Manhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.

1. Type and size shall match fittings to duct to be terminated.
2. Fittings shall align with elevations of approaching duct and be located near interior corners of manholes to facilitate racking of cable.

F. Ground Rod Sleeve: Provide a 3-inch PVC sleeve in manhole floors 2 inches from the wall adjacent to, but not underneath, the duct entering the structure.

G. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.

1.14 UTILITY STRUCTURE ACCESSORIES

A. Accessories for Utility Structures: Utility equipment and accessory items used for utility structure access and utility support, listed and labeled for intended use and application.

B. Manhole Frames, Covers, and Chimney Components: Comply with structural design loading specified for manhole.

1. Frame and Cover: Weatherproof, gray cast iron complying with ASTM A 48/A 48M, Class 30B with milled cover-to-frame bearing surfaces; diameter, 29 inches.
    a. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
    b. Special Covers: Recess in face of cover designed to accept finish material in paved areas.
2. Cover Legend: Cast in. Selected to suit system.

a. Legend: "ELECTRIC-LV" for duct systems with power wires and cables for systems operating at 600 V and less.
b. Legend: "ELECTRIC-HV" for duct systems with medium-voltage cables.

3. Manhole Chimney Components: Precast concrete rings with dimensions matched to those of roof opening.

a. Mortar for Chimney Ring and Frame and Cover Joints: Comply with ASTM C 270, Type M, except for quantities less than 2.0 cu. ft. where packaged mix complying with ASTM C 387, Type M, may be used.
b. Seal joints watertight using preformed plastic or rubber complying with ASTM C 990. Install sealing material according to sealant manufacturers' written instructions.

C. Manhole Sump Frame and Grate: ASTM A 48/A 48M, Class 30B, gray cast iron.

D. Pulling Eyes in Concrete Walls: Eyebolt with reinforcing-bar fastening insert, 2-inch-diameter eye, and 1-by-4-inch bolt.

1. Working Load Embedded in 6-Inch, 4000-psi (27.6-MPa) Concrete: 13,000-lbf (58-kN) minimum tension.

E. Pulling Eyes in Nonconcrete Walls: Eyebolt with reinforced fastening, 1-1/4-inch-diameter eye, rated 2500-lbf (11-kN) minimum tension.

F. Pulling-in and Lifting Irons in Concrete Floors: 7/8-inch- (22-mm-) diameter, hot-dip galvanized, bent steel rod; stress relieved after forming; and fastened to reinforcing rod. Exposed triangular opening.

1. Ultimate Yield Strength: 40,000-lbf (180-kN) shear and 60,000-lbf (270-kN) tension.

G. Bolting Inserts for Concrete Utility Structure Cable Racks and Other Attachments: Flared, threaded inserts of noncorrosive, chemical-resistant, nonconductive thermoplastic material; 1/2-inch (13-mm) ID by 2-3/4 inches (69 mm) deep, flared to 1-1/4 inches (31 mm) minimum at base.

1. Tested Ultimate Pullout Strength: 12,000 lbf (53 kN) minimum.

H. Ground Rod Sleeve: 3-inch (75-mm) PVC sleeve in manhole floors 2 inches (50 mm) from the wall adjacent to, but not underneath, the ducts routed from the facility.

I. Expansion Anchors for Installation after Concrete Is Cast: Zinc-plated, carbon-steel-wedge type with stainless-steel expander clip with 1/2-inch (13-mm) bolt, 5300-lbf (24-kN) rated pullout strength, and minimum 6800-lbf (30-kN) rated shear strength.

J. Cable Rack Assembly: Steel, hot-dip galvanized, except insulators.

1. Stanchions: T-section or channel with provisions to connect to other sections or channels to form a continuous unit; 1-1/2 inches (38 mm) in width by nominal 24 inches (600 mm) long; punched with 14 hook holes on 1-1/2-inch (38-mm) centers for cable-arm attachment.

2. Arms: 1-1/2 inches (38 mm) wide, lengths ranging from 3 inches (75 mm) with 450-lb (204-kg) minimum capacity to 18 inches (450 mm) with 250-lb (114-kg) minimum capacity. Arms shall have slots along full length for cable ties and be arranged for secure mounting in horizontal position at any vertical location on stanchions.
3. Insulators: High-glaze, wet-process porcelain arranged for mounting on cable arms.

K. Cable Rack Assembly: Nonmetallic. Components fabricated from nonconductive, fiberglass-reinforced polymer.

1. Stanchions: Nominal 36 inches (900 mm) high by 4 inches (100 mm) wide, with provisions to connect to other sections to form a continuous unit, with minimum of nine holes for arm attachment.
2. Arms: Arranged for secure, drop-in attachment in horizontal position at any location on cable stanchions, and capable of being locked in position. Arms shall be available in lengths ranging from 3 inches (75 mm) with 450-lb (204-kg) minimum capacity to 20 inches (500 mm) with 250-lb (114-kg) minimum capacity. Top of arm shall be nominally 4 inches (100 mm) wide, and arm shall have slots along full length for cable ties.

L. Duct-Sealing Compound: Non-hardening, safe for contact with human skin, not deleterious to cable insulation, and workable at temperatures as low as 35 deg F (2 deg C). Capable of withstanding temperature of 300 deg F (150 deg C) without slump and adhering to clean surfaces of plastic ducts, metallic conduit, conduit and duct coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and common metals.

M. Fixed Manhole Ladders: Arranged for attachment to roof of manhole. Ladder and mounting brackets and braces shall be fabricated from nonconductive, structural-grade, fiberglass-reinforced resin.

N. Cover Hooks: Heavy duty, designed for lifts 60 lbf (270 N) and greater. Two required.

1.15 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.

1.16 PREPARATION

A. Coordinate layout and installation of duct, duct bank, manholes, 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 Section 311000 "Site Clearing." Remove and stockpile topsoil for reapplication according to Section 311000 "Site Clearing."

1.17 UNDERGROUND DUCT APPLICATION

A. Duct for Electrical Cables More Than 600 V: Type EPC-40-PVC RNC, concrete-encased unless otherwise indicated.

B. Duct for Electrical Feeders 600 V and Less: Type EPC-40-PVC RNC, direct-buried unless otherwise indicated.

C. Duct for Electrical Branch Circuits: Type EPC-40-PVC RNC, direct-buried unless otherwise indicated.

D. Underground Ducts Crossing Paved Paths, Walks, and, Driveways, Roadways: Type EPC-40 PVC RNC, encased in reinforced concrete.

E. Stub-ups: Concrete-encased PVC-coated GRC.

1.18 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, Non-deliberate Loading by Heavy Vehicles: Precast concrete, AASHTO HB 17, H-20 structural load rating.
3. Units in Sidewalk and Similar Applications with a Safety Factor for Non-deliberate Loading by Vehicles: Precast concrete, AASHTO HB 17, H-10 structural load rating.
4. Units Subject to Light-Duty Pedestrian Traffic Only: Concrete, structurally tested according to SCTE 77 with 3000-lbf (13 345-N) vertical loading.
5. Cover design load shall not exceed the design load of the handhole or box.

B. Manholes: Precast concrete.

1. Units Located in Roadways and Other Deliberate Traffic Paths by Heavy or Medium Vehicles: H-20 structural load rating according to AASHTO HB 17.
2. Units Not Located in Deliberate Traffic Paths by Heavy or Medium Vehicles: H-10 load rating according to AASHTO HB 17.

1.19 EARTHWORK

A. Excavation and Backfill: Comply with Section 312000 "Earth Moving," but do not use heavy-duty, hydraulic-operated, compaction equipment.

B. Restore surface features at areas disturbed by excavation, and re-establish original grades unless otherwise indicated. Replace removed sod immediately after backfilling is completed.

C. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Comply with Section 329200 "Turf and Grasses" and Section 329300 "Plants."

D. Cut and patch existing pavement in the path of underground duct, duct bank, and underground structures according to "Cutting and Patching" Article in Section 017300 "Execution."

1.20 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 (1200 mm), 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 (250 mm) o.c. for 5-inch (125-mm) duct, and vary proportionately for other duct sizes.

1. Begin change from regular spacing to end-bell spacing 10 feet (3 m) 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 (19 mm).
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 (150 mm) o.c. for 4-inch (100-mm) duct, and vary proportionately for other duct sizes.

1. Begin change from regular spacing to terminator spacing 10 feet (3 m) 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 (19 mm).

I. Building Wall Penetrations: Make a transition from underground duct to GRC at least 10 feet (3 m) 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 260544 "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 (1.03-MPa) hydrostatic pressure.

K. Pulling Cord: Install 200-lbf- (1000-N-) 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 in Section 312000 "Earth Moving" for pipes less than 6 inches (150 mm) in nominal diameter.
2. Width: Excavate trench 12 inches (300 mm) wider than duct on each side.
3. Width: Excavate trench 3 inches (75 mm) wider than duct on each side.
4. Depth: Install so top of duct envelope is at least 24 inches (600 mm) below finished grade in areas not subject to deliberate traffic, and at least 30 inches

(750 mm) 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 (6 m) of duct. Place spacers within 24 inches (600 mm) of duct ends. Stagger spacers approximately 6 inches (150 mm) 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 (75 mm) between edge of duct and exterior envelope wall, 2 inches (50 mm) between ducts for like services, and 4 inches (100 mm) between power and communications ducts.
8. 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 (75 mm) of concrete.
    b. Stub-ups to Outdoor Equipment: Extend concrete-encased GRC horizontally a minimum of 60 inches (1500 mm) from edge of base. Install insulated grounding bushings on terminations at equipment.

        1) Stub-ups shall be minimum 4 inches (100 mm) above finished floor and minimum 3 inches (75 mm) from conduit side to edge of slab.

    c. Stub-ups to Indoor Equipment: Extend concrete-encased GRC horizontally a minimum of 60 inches (1500 mm) from edge of wall. Install insulated grounding bushings on terminations at equipment.

        1) Stub-ups shall be minimum 4 inches (100 mm) above finished floor and no less than 3 inches (75 mm) from conduit side to edge of slab.

9. 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.
10. 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.
11. Concrete Cover: Install a minimum of 3 inches (75 mm) of (red) concrete cover between edge of duct to exterior envelope wall, 2 inches (50 mm) between duct of like services, and 4 inches (100 mm) between power and communications ducts.
12. 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 (15-mm) reinforcing-rod dowels extending a minimum of 18 inches (450 mm) into concrete on both sides of joint near corners of envelope.

13. Pouring Concrete: Comply with requirements in "Concrete Placement" Article in Section 033000 "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 in Section 312000 "Earth Moving" for preparation of trench bottoms for pipes less than 6 inches (150 mm) in nominal diameter.
2. Width: Excavate trench 12 inches (300 mm) wider than duct on each side.
3. Width: Excavate trench 3 inches (75 mm) wider than duct on each side.
4. Depth: Install top of duct at least 36 inches (900 mm) 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 (6 m) of duct. Place spacers within 24 inches (600 mm) of duct ends. Stagger spacers approximately 6 inches (150 mm) 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 (75 mm) between ducts for like services and 6 inches (150 mm) 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 (75 mm) of concrete.
    b. Stub-ups to Outdoor Equipment: Extend concrete-encased GRC horizontally a minimum of 60 inches (1500 mm) from edge of base. Install insulated grounding bushings on terminations at equipment.

        1) Stub-ups shall be minimum 4 inches (100 mm) above finished floor and minimum 3 inches (75 mm) from conduit side to edge of slab.

    c. Stub-ups to Indoor Equipment: Extend concrete-encased GRC horizontally a minimum of 60 inches (1500 mm) from edge of wall. Install insulated grounding bushings on terminations at equipment.

1) Stub-ups shall be minimum 4 inches (100 mm) above finished floor and no less than 3 inches (75 mm) 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 (100 mm) 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 (75 mm) of sand as a bed for duct. Place sand to a minimum of 6 inches (150 mm) above top level of duct.
    b. Place minimum 6 inches (150 mm) of engineered fill above concrete encasement of duct.

N. Warning Planks: Bury warning planks approximately 12 inches (300 mm) above direct-buried duct, placing them 24 inches (600 mm) o.c. Align planks along the width and along the centerline of duct or duct bank. Provide an additional plank for each 12-inch (300-mm) increment of duct-bank width over a nominal 18 inches (450 mm). Space additional planks 12 inches (300 mm) apart, horizontally.

O. Underground-Line Warning Tape: Bury nonconducting underground line specified in Section 260553 "Identification for Electrical Systems" no less than 12 inches (300 mm) above all concrete-encased duct and duct banks and approximately 12 inches (300 mm) below grade. Align tape parallel to and within 3 inches (75 mm) of centerline of duct bank. Provide an additional warning tape for each 12-inch (300-mm) increment of duct-bank width over a nominal 18 inches (450 mm). Space additional tapes 12 inches (300 mm) apart, horizontally.

1.21 INSTALLATION OF CONCRETE MANHOLES, HANDHOLES, AND BOXES

A. Cast-in-Place Manhole Installation:

1. Finish interior surfaces with a smooth-troweled finish.
2. Knockouts for Future Duct Connections: Form and pour concrete knockout panels 1-1/2 to 2 inches (38 to 50 mm) thick, arranged as indicated.
3. Comply with requirements in Section 033000 "Cast-in-Place Concrete" for cast-in-place concrete, formwork, and reinforcement.

B. Precast Concrete Handhole and Manhole 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 (25-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.

C. Elevations:

1. Manhole Roof: Install with rooftop at least 15 inches (375 mm) below finished grade.
2. Manhole Frame: In paved areas and trafficways, set frames flush with finished grade. Set other manhole frames 1 inch (25 mm) above finished grade.
3. Install handholes with bottom below frost line.
4. Handhole Covers: In paved areas and trafficways, set surface flush with finished grade. Set covers of other handholes 1 inch (25 mm) above finished grade.
5. Where indicated, cast handhole cover frame integrally with handhole structure.

D. Drainage: Install drains in bottom of manholes where indicated. Coordinate with drainage provisions indicated.

E. 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.

F. Waterproofing: Apply waterproofing to exterior surfaces of manholes and handholes after concrete has cured at least three days. Waterproofing materials and installation are specified in Section 071353 "Elastomeric 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.

G. Dampproofing: Apply dampproofing to exterior surfaces of manholes and handholes after concrete has cured at least three days. Dampproofing materials and installation are specified in Section 071113 "Bituminous Dampproofing." After ducts are connected and grouted, and before backfilling, dampproof joints and connections, and touch up abrasions and scars. Dampproof exterior of manhole chimneys after mortar has cured at least three days.

H. Hardware: Install removable hardware, including pulling eyes, cable stanchions, and cable arms, as required for installation and support of cables and conductors and as indicated.

I. Fixed Manhole Ladders: Arrange to provide for safe entry with maximum clearance from cables and other items in manholes.

J. Field-Installed Bolting Anchors in Manholes and Concrete Handholes: Do not drill deeper than 3-7/8 inches (97 mm) for manholes and 2 inches (50 mm) for handholes, for anchor bolts installed in the field. Use a minimum of two anchors for each cable stanchion.

1.22 GROUNDING

A. Ground underground ducts and utility structures according to Section 260526 "Grounding and Bonding for Electrical Systems."

1.23 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-(300-mm-) long mandrel equal to duct size minus 1/4 inch (6 mm). If obstructions are indicated, remove obstructions and retest.
3. Test manhole and handhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Section 260526 "Grounding and Bonding for Electrical Systems."

B. Correct deficiencies and retest as specified above to demonstrate compliance.

C. Prepare test and inspection reports.

1.24 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 260543

SECTION 260544 - SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

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 078413 "Penetration 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.

1.4 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.

1.5 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.

1.6 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.

1.7 GROUT

A. Description: Nonshrink; 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.

1.8 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, nonshrinking foam.

1.9 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 079200 "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 or unless seismic criteria require different clearance.
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.

1.10 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.

1.11 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 260544

SECTION 260548.16 - SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

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. Restraint channel bracings.
2. Restraint cables.
3. Seismic-restraint accessories.
4. Mechanical anchor bolts.
5. Adhesive anchor bolts.

B. Related Requirements:

1. Section 260529 "Hangers and Supports for Electrical Systems" for commonly used electrical supports and installation requirements.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.

    a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an agency acceptable to authorities having jurisdiction.
    b. Annotate to indicate application of each product submitted and compliance with requirements.

B. Delegated-Design Submittal: For each seismic-restraint device.

1. Include design calculations and details for selecting seismic restraints complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
2. Design Calculations: Calculate static and dynamic loading caused by equipment weight, operation, and seismic and wind forces required to select seismic and wind restraints and for designing vibration isolation bases.

    a. Coordinate design calculations with wind load calculations required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.

3. Seismic- and Wind-Restraint Details:

a. Design Analysis: To support selection and arrangement of seismic and wind restraints. Include calculations of combined tensile and shear loads.
b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.
d. Preapproval and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of seismic bracing for electrical components with other systems and equipment in the vicinity, including other supports and seismic restraints. Electrical components include:

1. Control and monitoring panels.
2. Generators.
3. Luminaires.
4. Motor control centers.
5. Panelboards.
6. Photovoltaic system components.
7. Substations.
8. Switchboards.
9. Switchgear.
10. Transformers.
11. Unit substations.

B. Qualification Data: For professional engineer and testing agency.

C. Welding certificates.

D. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated and that is acceptable to authorities having jurisdiction.

B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

C. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis. They shall bear anchorage preapproval from OSHPD in addition to preapproval, showing maximum seismic-restraint ratings, by ICC-ES or another agency acceptable to authorities having jurisdiction. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) that support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

E. Comply with NFPA 70.

1.6 PERFORMANCE REQUIREMENTS

A. Wind-Restraint Loading:

1. Basic Wind Speed: As indicated on the structural plans.
2. Building Classification Category: As indicated on the architectural plans.
3. Minimum 10 lb/sq. ft. multiplied by maximum area of component projected on vertical plane normal to wind direction and 45 degrees either side of normal.

B. Seismic-Restraint Loading:

1. Site Class as Defined in the IBC: As indicated on the structural plans.
2. Assigned Seismic Use Group or Building Category as Defined in the IBC: As indicated on the architectural plans.

1.7 RESTRAINT CHANNEL BRACINGS

A. Description: MFMA-4, shop- or field-fabricated bracing assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end, with other matching components, and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

1.8 RESTRAINT CABLES

A. Restraint Cables: ASTM A 603 galvanized-steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; with a minimum of two clamping bolts for cable engagement.

1.9 SEISMIC-RESTRAINT ACCESSORIES

A. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.

B. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid channel bracings and restraint cables.

C. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings and matched to type and size of anchor bolts and studs.

D. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings and matched to type and size of attachment devices used.

E. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

1.10 MECHANICAL ANCHOR BOLTS

A. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

1.11 ADHESIVE ANCHOR BOLTS

A. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing PVC or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

1.12 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for reinforcement and cast-in-place anchors to verify actual locations before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

1.13 APPLICATIONS

A. Multiple Raceways or Cables: Secure raceways and cables to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.

B. Hanger-Rod Stiffeners: Install hanger-rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods caused by seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

1.14 SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete.

B. Equipment and Hanger Restraints:

1. Install resilient, bolt-isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
2. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

E. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

F. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

1.15 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in runs of raceways, cables, wireways, cable trays, and busways where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where connection is terminated to

equipment that is anchored to a different structural element from the one supporting them as they approach equipment.

1.16 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
5. Test to 90 percent of rated proof load of device.

B. Seismic controls will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

1.17 ADJUSTING

A. Adjust restraints to permit free movement of equipment within normal mode of operation.

END OF SECTION 260548.16

SECTION 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

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. Labels.
2. Bands and tubes.
3. Tapes and stencils.
4. Tags.
5. Signs.
6. Cable ties.
7. Miscellaneous identification products.

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.

1.4 MANUFACTURERS

A. Manufacturer’s Standard Products: Where more than one type is listed for a specified application, selection is Installer’s option, but provide single type for each application category.

B. Plasticized Card-Stock Tags: Vinyl cloth with preprinted and field-printed legends. Orange background, except as otherwise indicated, with eyelet for fastener.

C. Aluminum-Faced Card-Stock Tags: Weather-resistant, 18-point minimum card stock faced on both sides with embossable aluminum sheet, 0.002 inch thick, laminated with moisture-resistant acrylic adhesive, and punched for the fastener. Preprinted legends suit each application.

1.5 ENGRAVED NAMEPLATES AND SIGNS

A. Engraved Legend:

1. Normal Power – White letters on black face, unless noted otherwise on Drawings.
2. Emergency Power – White letters on red face, unless noted otherwise on Drawings.
3. UPS Power – White letters on blue face, unless noted otherwise on Drawings.

1.6 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 260573.19 "Arc-Flash Hazard Analysis"**] 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**] <**Insert temperature change**>.

1.7 COLOR AND LEGEND REQUIREMENTS

A. Raceways and Cables Carrying Circuits at 600 V or Less:

1. [**Black letters on an orange field**] <**Insert color scheme**>.
2. Legend: Indicate voltage[**and system or service type**].

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[**or field applied for sizes larger than No. 8 AWG if authorities having jurisdiction permit**].

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**] [**or**] [**gray**].
6. Color for Equipment Grounds: [**Bare copper**] [**Green**] [**Green with a yellow stripe**].
7. Colors for Isolated Grounds: Green with two or more yellow stripes.

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.
2. <**Insert colors**>.

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."
3. <**Insert names and wording of warning signs or labels (for example, arc flash, multiple services and voltages, and others**>.

F. Equipment Identification Labels:

1. Black letters on a white field.
2. <**Insert specific requirements for equipment to be labeled, such as transformers, panelboards, etc.**>

1.8 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.
i. Seton Identification Products; a Brady Corporation company.

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.
e. Seton Identification Products; a Brady Corporation company.

C. Self-Adhesive Wraparound Labels: [**Preprinted**] [**Write-on**], 3-mil-thick, [**polyester**] [**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.
j. Seton Identification Products; a Brady Corporation company.

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:

    a. Permanent, waterproof, black ink marker recommended by tag manufacturer.
    b. Machine-printed, permanent, waterproof, black ink recommended by printer manufacturer.

D. Self-Adhesive Labels: [**Polyester**] [**Vinyl**], thermal, transfer-printed, 3-mil-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 for raceway and conductors.
    b. 3-1/2 by 5 inches for equipment.
    c. As required by authorities having jurisdiction.

1.9 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.
    d. Panduit Corp.

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 one of the following:

    a. Brady Corporation.
    b. Panduit Corp.

1.10 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.
    f. Panduit Corp.

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.
    d. Marking Services, Inc.

C. Tape and Stencil: 4-inch-wide black stripes on 10-inch centers placed diagonally over orange background and are 12 inches wide. Stop stripes at legends.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Brimar Industries, Inc.
    b. HellermannTyton.
    c. LEM Products Inc.
    d. Marking Services, Inc.
    e. Seton Identification Products; a Brady Corporation company.

D. Floor Marking Tape: 2-inch-wide, 5-mil pressure-sensitive vinyl tape, with [**black and white**] [**yellow and black**] stripes and clear vinyl overlay.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Carlton Industries, LP.
    b. Seton Identification Products; a Brady Corporation company.

E. Underground-Line Warning Tape:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Brady Corporation.
    b. Brimar Industries, Inc.
    c. Ideal Industries, Inc.
    d. LEM Products Inc.

e. Marking Services, Inc.
f. Reef Industries, Inc.
g. Seton Identification Products; a Brady Corporation company.

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" <**Insert inscription**>.
c. Inscriptions for Orange-Colored Tapes: "TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE" <**Insert inscription**>.

4. Tape [**Type I**] <**Insert drawing designation**>:

a. 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: 4 mils.
d. Weight: 18.5 lb/1000 sq. ft..
e. Tensile according to ASTM D882: 30 lbf and 2500 psi.

5. Tape [**Type II**] <**Insert drawing designation**>:

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 D882: 400 lbf and 11,500 psi.

6. Tape [**Type ID**] <**Insert drawing designation**>:

a. Detectable three-layer laminate, consisting of a printed pigmented polyolefin film, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core; bright colored,

[**continuous-printed on one side with the inscription of the utility,**]compounded for direct-burial service.
b. Width: 3 inches.
c. Overall Thickness: 5 mils.
d. Foil Core Thickness: 0.35 mil.
e. Weight: 28 lb/1000 sq. ft..
f. Tensile according to ASTM D882: 70 lbf and 4600 psi.

7. Tape [**Type IID**] <**Insert drawing designation**>:

a. Reinforced, detectable three-layer laminate, consisting of a printed pigmented woven scrim, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core; bright-colored, [**continuous-printed on one side with the inscription of the utility,**]compounded for direct-burial service.
b. Width: 3 inches.
c. Overall Thickness: 8 mils.
d. Foil Core Thickness: 0.35 mil.
e. Weight: 34 lb/1000 sq. ft..
f. Tensile according to ASTM D882: 300 lbf and 12,500 psi.

F. Stenciled Legend: In nonfading, waterproof, [**black**] <**Insert color**> ink or paint. Minimum letter height shall be [**1 inch**] <**Insert dimension**>.

1.11 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.
e. Seton Identification Products; a Brady Corporation company.

B. Nonmetallic Preprinted Tags: Polyethylene tags, [**0.015 inch**] [**0.023 inch**] thick, color-coded for phase and voltage level, with factory [**screened**] [**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.
h. Seton Identification Products; a Brady Corporation company.

C. Write-on Tags:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Brimar Industries, Inc.
b. Carlton Industries, LP.
c. LEM Products Inc.
d. Seton Identification Products; a Brady Corporation company.

2. Polyester Tags: [**0.010 inch**] [**0.015 inch**] <**Insert dimension**> thick, with corrosion-resistant grommet and cable tie for attachment.
3. Marker for Tags:

a. Permanent, waterproof, black ink marker recommended by tag manufacturer.
b. Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

1.12 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.
d. Marking Services, Inc.

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.
d. Marking Services, Inc.

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.
   d. Marking Services, Inc.

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**] [**white letters on a dark gray background**] <**Insert colors**>.
   d. [**Punched or drilled for mechanical fasteners with 1/4-inch grommets in corners for mounting**] [**Self-adhesive**].
   e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

1.13 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.
4. Panduit Corp.

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 D638: 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 D638: 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 D638: 7000 psi.
3. UL 94 Flame Rating: 94V-0.
4. Temperature Range: Minus 50 to plus 284 deg F.
5. Color: Black.

1.14 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.

1.15 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.

1.16 INSTALLATION

Consider the following items where editing 3.2 INSTALLATION]

A. Identify feeders over 600 V labeled with “DANGER—HIGH VOLTAGE” with black letters 2 inches high, stenciled with paint at 10-foot intervals over a continuous, painted orange background. Identify the following:

1. Entire surface of exposed conduits.

B. Install painted identification as follows:

1. Clean surfaces of dust, loose material, and oily films before painting.
2. Prime Surfaces: For galvanized metal, use single-component, acrylic vehicle coating formulated for galvanized surfaces. For concrete masonry units, use heavy-duty, acrylic-resin block filler. For concrete surfaces, use clear, alkali-resistant, alkyd binder-type sealer.
3. Apply one intermediate and one finish coat of silicone alkyd enamel.

4. Apply primer and finish materials according to manufacturer's instructions.

    a. Identify Raceways and Exposed Cables with Color Banding: Band exposed and accessible raceways of the systems listed below for identification.

5. 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. Telecommunications System – [Green and Yellow]
        1) Install Circuit Identification Labels on Boxes: Label externally as follows:
            a) xxxx

6. Exposed Boxes: Pressure-sensitive, self-adhesive plastic label on cover.
7. Concealed Boxes: Plasticized cardstock tags.
8. Labeling Legend: Permanent, waterproof listing of panel and circuit number or equivalent.

C. Color-Code Conductors:

1. 208/120-V System: As follows:

    a. Neutral – White
    b. Ground – Green

2. 480-277-V System: As follows;

    a. Neutral – Grey
    b. Ground – Green

3. Factory-apply color the entire length of the conductors, except the following field-applied, color-coding methods may be used in lieu of factory-coded wire for phase conductors sizes larger than No. 10 AWG and grounded conductors and grounding conductors larger than No. 6 AWG.

    a. Colored cable ties applied in groups of 3 ties of specified color to each wire at each terminal or splice point starting 3 inches from the terminal and spaced 3 inches apart. Apply with a special tool or pliers, tighten to a snug fit, and cut off excess length.

4. Power Circuit Identification: Fasten bands using integral ears.

D. Apply identification to conductors as follows:

1. **Conductors to be Extended in the Future: Indicate circuit numbers.**
2. **Multiple Power or Lighting Circuits in the same Enclosure: Identify each conductor with source, voltage, circuit number, and phase. Use color coding for voltage and phase indication of secondary circuit.**
3. **Multiple control and Communications Circuits in the same Enclosure: Identify each conductor by its system and circuit designation. Use a consistent system of tags, color coding, or cable marking tape.**

E. Apply warning, caution, and instruction signs and stencils as follows:

1. **Install warning, caution, and instruction signs where indicated or required to ensure safe operation and maintenance of electrical systems and of items to which they connect. Install engraved, plastic-laminated instruction signs with approved legend where instructions or explanations are needed for system or equipment operation. Install butyrate signs with metal backing for outdoor items.**
2. **Emergency-Operating Signs: Install engraved laminate signs.**

F. Install identification as follows:

1. **Use white lettering on black field.**

Example: Panel 1H1 120/208V, 3-ph, 4-wire fed from Panel MDR-CCT#4

a. Switches and receptacles.
b. Rectifiers.
c. Frequency converters.
d. Telephone switching equipment.
e. Clock/program master equipment.
f. Call system master station.
g. TV/audio monitoring master station.
h. Fire-alarm master station or control panel.
i. Security-monitoring master station or control panel.

2. **Circuits: Apply identification labels of engraved plastic laminate on each switch and receptacle indicating panelboard and circuit number supplying receptacle.**

G. **For panelboards, provide framed, typed circuit schedules with explicit description and identification of items controlled by each individual breaker.**

H. 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.

I. Install identifying devices before installing acoustical ceilings and similar concealment.

J. Verify identity of each item before installing identification products.

K. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.

L. Apply identification devices to surfaces that require finish after completing finish work.

M. Install signs with approved legend to facilitate proper identification, operation, and maintenance of electrical systems and connected items.

N. 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.

O. 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.

P. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.

Q. Emergency 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**] [**load shedding**] <**Insert emergency operations**>.

R. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from the floor.

S. 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. "EMERGENCY POWER."
2. "POWER."
3. "UPS."
4. <**Insert name**>.

T. 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.

U. Snap-around Labels: Secure tight to surface at a location with high visibility and accessibility.

V. Self-Adhesive Wraparound Labels: Secure tight to surface at a location with high visibility and accessibility.

W. 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.

X. Snap-around Color-Coding Bands: Secure tight to surface at a location with high visibility and accessibility.

Y. Heat-Shrink, Preprinted Tubes: Secure tight to surface at a location with high visibility and accessibility.

Z. Marker Tapes: Secure tight to surface at a location with high visibility and accessibility.

AA. 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.

BB. Tape and Stencil: Comply with requirements in painting Sections for surface preparation and paint application.

CC. Floor Marking Tape: Apply stripes to finished surfaces following manufacturer's written instructions.

DD. 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.

EE. Metal Tags:

1. Place in a location with high visibility and accessibility.
2. Secure using [**general-purpose**] [**UV-stabilized**] [**plenum-rated**] cable ties.

FF. Nonmetallic Preprinted Tags:

1. Place in a location with high visibility and accessibility.

2. Secure using [**general-purpose**] [**UV-stabilized**] [**plenum-rated**] cable ties.

GG. Write-on Tags:

1. Place in a location with high visibility and accessibility.
2. Secure using [**general-purpose**] [**UV-stabilized**] [**plenum-rated**] cable ties.

HH. 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.

II. 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.

JJ. 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.

KK. Cable Ties: General purpose, for attaching tags, except as listed below:

1. Outdoors: UV-stabilized nylon.
2. In Spaces Handling Environmental Air: Plenum rated.

1.17 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**] [**30-foot**] maximum intervals.

D. Accessible Raceways, Armored and Metal-Clad Cables, More Than 600 V: [**Vinyl wraparound labels**] [**Snap-around labels**] [**Self-adhesive labels**] [**Snap-around color-coding bands for raceway and cables**].

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.

E. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits, More Than [**30**] <**Insert number**> A and [**120**] <**Insert number**> V to Ground: Identify with self-adhesive [**raceway labels**] [**vinyl tape applied in bands**].

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. 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. "EMERGENCY POWER."
2. "POWER."
3. "UPS."
4. <**Insert name**>.

G. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use [**vinyl wraparound labels**] [**self-adhesive wraparound labels**] [**snap-around labels**] [**snap-around color-coding bands**] [**self-adhesive vinyl tape**] 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.

H. Power-Circuit Conductor Identification, More Than 600 V: For conductors in vaults, pull and junction boxes, manholes, and handholes, use [**write-on tags**] [**nonmetallic preprinted tags colored and marked to indicate phase, and a separate tag with the circuit designation**].

I. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes, manholes, and handholes, use [**write-on tags**] [**self-adhesive labels**] with the conductor or cable designation, origin, and destination.

J. Control-Circuit Conductor Termination Identification: For identification at terminations, provide [**heat-shrink preprinted tubes**] [**self-adhesive labels**] with the conductor designation.

K. Conductors to Be Extended in the Future: Attach [**write-on tags**] [**marker tape**] to conductors[**and list source**].

L. Auxiliary Electrical Systems Conductor Identification: [**Marker tape**] [**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.

M. Locations of Underground Lines: Underground-line warning tape for power, lighting, communication, and control wiring and optical-fiber cable.

N. 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.

O. Workspace Indication: Apply [**floor marking tape**] [**or**] [**tape and stencil**] 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.

P. Instructional Signs: Self-adhesive labels, including the color code for grounded and ungrounded conductors.

Q. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: [**Self-adhesive labels**] [**Baked-enamel warning signs**] [**Metal-backed, butyrate 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.
c. <**Insert items**>.

R. Arc Flash Warning Labeling: Self-adhesive labels.

S. Operating Instruction Signs: [**Self-adhesive labels**] [**Baked-enamel warning signs**] [**Metal-backed, butyrate warning signs**] [**Laminated acrylic or melamine plastic signs**].

T. Emergency Operating Instruction Signs: [**Self-adhesive labels**] [**Baked-enamel warning signs**] [**Metal-backed, butyrate warning signs**] [**Laminated acrylic or melamine plastic signs**] with white legend on a red background with minimum 3/8-

inch-high letters for emergency instructions at equipment used for [**power transfer**] [**load shedding**] <**Insert emergency operations**>.

U. Equipment Identification Labels:

1. Indoor Equipment: [**Self-adhesive label**] [**Baked-enamel signs**] [**Metal-backed butyrate signs**] [**Laminated acrylic or melamine plastic sign**].
2. Outdoor Equipment: [**Laminated acrylic or melamine sign**] [**Stenciled legend 4 inches high**].
3. 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 [**self-adhesive, engraved,**] [**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.
    w. <**Insert equipment**>.

END OF SECTION 260553

SECTION 260572 - OVERCURRENT PROTECTIVE DEVICE SHORT-CIRCUIT STUDY

1.1 GENERAL

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 may 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.

1.7 COMPUTER SOFTWARE

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. SKM Systems Analysis, Inc.

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.

1.8 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.

1.9 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).

1.10 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.

1.11 ADJUSTING

A. Make minor modifications to equipment as required to accomplish compliance with short-circuit study.

1.12 DEMONSTRATION

A. Train Owner's operating and maintenance personnel in the use of study results.

END OF SECTION 260572

SECTION 260573 - OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY

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.

B. Coordination study shall be completed prior to the ordering or installation of equipment to insure that equipment ratings and configurations are suitable and compatible with the Coordination study.

C. Selective coordination shall meet the requirements of NFPA 70 and 99. Specifically, all inpatient areas shall meet the requirements of 2014 NFPA 70, Article 517.

1.3 DEFINITIONS

A. 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.

B. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.

C. SCCR: Short-circuit current rating.

D. 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 and 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 017823 "Operation and Maintenance Data," 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.

1.8 COMPUTER SOFTWARE DEVELOPERS

A. Software Developers:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

    a. SKM Systems Analysis, Inc.

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.

1.9 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 260572 "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.

1.10 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.

1.11 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. Unit substation primary and secondary terminals.
4. Low-voltage switchgear.
5. Motor-control centers.
6. Standby generators and automatic transfer switches.
7. 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.

1.12 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.

1.13 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, voltage sags so as not to affect the operation of other utilization equipment on the system supplying the motor.

1.14 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.

1.15 FIELD ADJUSTING

A. The Owner’s Testing Agency will adjust relay and protective device settings according to the recommended settings provided by the coordination study.

1. Digital photos of all set devices clearly indicating settings, shall be taken and submitted with the project closeout documents. Photos shall be clearly labeled and organized by system and equipment.

B. Testing and adjusting shall be by a full-time employee of the Field Testing 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.

1.16 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 260573

SECTION 260574 - OVERCURRENT PROTECTIVE DEVICE ARC-FLASH STUDY

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.

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 017823 "Operation and Maintenance Data," 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.

1.8 COMPUTER SOFTWARE DEVELOPERS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. SKM Systems Analysis, Inc.

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.

1.9 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 260572 "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 260573 "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.

1.10 ARC-FLASH WARNING LABELS

A. Comply with requirements in Section 260553 "Identification for Electrical Systems" for self-adhesive equipment labels. Produce a 3.5-by-5-inch (76-by-127-mm) 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.

1.11 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.

1.12 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 260572 "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 260573 "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.

1.13 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. 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.

1.14 LABELING

A. Apply one arc-flash label for 480-V ac, and 208-V ac panelboards and disconnects and for each of the following locations:

1. All medium voltage equipment.

2. All low-voltage switchboards and switchgear.
3. All control panels.

1.15 APPLICATION OF WARNING LABELS

A. Install the arc-fault warning labels under the direct supervision and control of the Arc-Flash Study Specialist.

1.16 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 SECTION 260574

SECTION 260800 - ELECTRICAL FACILITY STARTUP/COMMISSIONING

1.1 DESCRIPTION

A. Scope of The Work

1. The purpose of this section is to specify Division 26 responsibilities and participation in the commissioning process. The owner will hire the Commissioning Authority for the project.
2. The Owner will hire the independent electrical testing agency as denoted in Section
   26 0880. The Commissioning Authority will coordinate the activities of the electrical testing firm.
3. 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.
4. The Contractor is responsible for performing testing of electrical equipment where identified in other specification sections.

B. Minimum requirements for Contractor:

1. CLEANING: ALL ELECTRICAL EQUIPMENT, INCLUDING BUT NOT LIMITED TO PANELBOARDS, SWITCHBOARDS, SWITCHGEAR, TRANSFORMERS, ATS'S, RACEWAYS, BOXES, AND CABINETS SHALL BE THOROUGHLY CLEANED OF ALL DIRT, DUST AND DEBRIS PRIOR TO THE COMMENCEMENT OF ANY TESTING. EQUIPMENT NOT THOROUGHLY CLEANED SHALL BE CONSIDERED NOT READY FOR STARTUP OR COMMISSIONING.
2. Start-up and testing of the equipment supplied.
3. Operate and maintain equipment and systems as required for commissioning tests.
4. Providing qualified personnel including equipment manufacturer's service technicians for
   participation with the commissioning team.
5. Provide equipment, materials, and labor necessary to correct deficiencies found during the commissioning process, which fulfill contract and warranty requirements.
6. Provide operation and maintenance information and record drawings for verification, organization, and distribution.
7. Provide assistance to the Commissioning Authority (CA) to develop and edit equipment startup and testing schedules (Commissioning Matrix).
8. Provide training for the systems specified in this division with coordination by the Contract Administrator and Commissioning Authority.
9. 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.

1.4 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.

1.5 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.

1.6 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.

1.7 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.

1.8 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.

1.9 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 260800

SECTION 260880 - ELECTRICAL ACCEPTANCE TESTING

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 Owner shall engage and pay for the services of a recognized independent Electrical Testing Agency for the purpose of performing the independent inspections, tests, adjustments and settings as specified herein and in other sections.

B. Contractor to provide support to the Testing Agency for performance of tests. Assist with scheduling and coordination of tests. Assist with support for required operation of equipment for tests.

C. The Electrical Testing Agency shall provide all material, equipment, labor, and technical supervision to perform such tests and inspections.

D. The Electrical Testing Agency shall submit appropriate documentation to demonstrate that it satisfactorily complies with the following. An organization having a “Full Membership” classification issued by the International Electrical Testing Association.

1. The Electrical Testing Agency shall be an independent, third party, testing organization which can function as an unbiased testing authority, professionally independent of the manufacturers, suppliers, and installers of equipment or systems evaluated by the testing organization.
2. The Electrical Testing Agency shall be regularly engaged in the testing of electrical equipment devices, installations, and systems.

E. The Electrical Testing Agency shall utilize technicians who are regularly employed for testing services.

F. 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. The following is a list of equipment and systems to be inspected, tested and calibrated by the Electrical Testing Agency. Refer to these specification sections for tests required.

Section Number	Section Title Equipment / System
263600	Transfer Switches
260513	Medium Voltage Cables
260519	Low-Voltage Electrical Power Conductors And Cables
261219	Pad Mounted, Liquid Filled, Medium Voltage Transformers
261323	Medium Voltage, Metal Enclosed Switchgear
261329	Medium Voltage, Pad Mounted Switchgear
262420	Hospital Isolated Distribution System
262413	Switchboards
260573	Overcurrent Protective Device Coordination Study (Note 1)
260526	Grounding and Bonding of Electrical Systems
262200	Low Voltage Transformers
26 3213.16	Gas-Engine-Driven Generator Sets
26 1300	15kv Indoor Metal-Clad Switchgear

Notes:

1. The Electrical Testing Agency will be responsible for adjusting and setting of all overcurrent device relay and trip settings according to the Coordination Study.

C. Provide tests as described in the following referenced code sections:

1. NFPA 99: Patient Area Grounding Systems
2. NFPA 99: Patient Care Area Receptacles
3. NFPA 99: Isolated Power System
4. NFPA 70: Ground Fault Protection Systems
5. NFPA 110: Level 1 EPSS

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 – 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 Commissioning Requirements.
3. Project ELECTRICAL SYSTEM PROTECTIVE DEVICE STUDY – refer to Section 26 0573.
4. Manufacturer’s instruction manuals applicable to each particular apparatus.
5. 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.
   f. Photo documentation of all breaker settings.

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 260500, "COMMON WORK RESULTS FOR ELECTRICAL, Submittals."

1.7 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-2013.

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.

1.8 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.

1.9 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 Commissioning Authority 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.

1.10 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 260880

SECTION 260923 - LIGHTING CONTROL DEVICE

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. Time switches.
2. Photoelectric switches.
3. Standalone daylight-harvesting switching and dimming controls.
4. Indoor occupancy and vacancy sensors.
5. Switchbox-mounted occupancy sensors.
6. Digital timer light switches.
7. High-bay occupancy sensors.
8. Extreme temperature occupancy sensors.
9. Outdoor motion sensors.
10. Lighting contactors.
11. Emergency shunt relays.

B. Related Requirements:

1. Section 262726 "Wiring Devices" for wall-box dimmers, non-networkable wall-switch occupancy sensors, and manual light switches.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Show installation details for the following:

a. Occupancy sensors.
b. Vacancy sensors.

2. Interconnection diagrams showing field-installed wiring.
3. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and elevations, 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. Structural members to which equipment will be attached.
3. Items penetrating finished ceiling, including the following:
    a. Luminaires.
    b. Air outlets and inlets.
    c. Speakers.
    d. Sprinklers.
    e. Access panels.
    f. Control modules.

B. Field quality-control reports.

C. Sample Warranty: For manufacturer's warranties.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of lighting control device to include in operation and maintenance manuals.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On USB media. Provide names, versions, and website addresses for locations of installed software.
3. Device address list.
4. Printout of software application and graphic screens.

1.6 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace lighting control devices that fail(s) in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:
    a. Faulty operation of lighting control software.
    b. Faulty operation of lighting control devices.
2. Warranty Period: Two year(s) from date of Substantial Completion.

1.7 DAYLIGHT-HARVESTING DIMMING CONTROLS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Hubbell Building Automation, Inc.
2. Lithonia Lighting; Acuity Brands Lighting, Inc.
3. WattStopper; a Legrand® Group brand.
4. Crestron

B. System Description: Sensing daylight and electrical lighting levels, the system adjusts the indoor electrical lighting levels. As daylight increases, the lights are dimmed.

1. Lighting control set point is based on two lighting conditions:

a. When no daylight is present (target level).
b. When significant daylight is present.

2. System programming is done with two hand-held, remote-control tools.

a. Initial setup tool.
b. Tool for occupants to adjust the target levels by increasing the set point up to 25 percent, or by minimizing the electric lighting level.

C. Ceiling-Mounted Dimming Controls: Solid-state, light-level sensor unit, with integrated power pack mounted on luminaire, to detect changes in indoor lighting levels that are perceived by the eye.

D. Electrical Components, Devices, and Accessories:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Sensor Output: 0- to 10-V dc to operate luminaires. Sensor is powered by controller unit.
3. Light-Level Sensor Set-Point Adjustment Range: 20 to 60 fc (120 to 640 lux).

E. Power Pack: Digital controller capable of accepting 3 RJ45 inputs with one outputs rated for 20-A incandescent or LED load at 120- and 277-V ac, for 16-A LED at 120- and 277-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc Class 2 power source, as defined by NFPA 70.

1. With integral current monitoring

a. Compatible with digital addressable lighting interface.

1) Plenum rated.

1.8 INDOOR OCCUPANCYAND VACANCY SENSORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Hubbell Building Automation, Inc.
2. Lithonia Lighting; Acuity Brands Lighting, Inc.
3. Sensor Switch, Inc.
4. WattStopper; a Legrand® Group brand.
5. *ADDENDUM 01> IR-TEC <ADDENDUM 01*

B. General Requirements for Sensors:

1. Wall and Ceiling-mounted, solid-state indoor occupancy and vacancy sensors.
2. Dual technology.

3. Integrated power pack.
4. Hardwired connection to switch; and BAS and lighting control system.
5. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
6. Operation:
    a. Occupancy Sensor: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn them off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
    b. Vacancy Sensor: Unless otherwise indicated, lights are manually turned on and sensor turns lights off when the room is unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
    c. Combination Sensor: Unless otherwise indicated, sensor shall be programmed to turn lights on when coverage area is occupied and turn them off when unoccupied, or to turn off lights that have been manually turned on; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
7. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A.
8. Power: Line voltage.
9. Power Pack: Dry contacts rated for 20-A ballast or LED load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.
10. Mounting:
    a. Sensor: Suitable for mounting in any position on a standard outlet box.
    b. Relay: Externally mounted through a 1/2-inch (13-mm) knockout in a standard electrical enclosure.
    c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
11. Indicator: Digital display, to show when motion is detected during testing and normal operation of sensor.
12. Bypass Switch: Override the "on" function in case of sensor failure.
13. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc (21.5 to 2152 lux); turn lights off when selected lighting level is present.

C. Dual-Technology Type: Wall or Ceiling mounted; detect occupants in coverage area using PIR and ultrasonic detection methods. The particular technology or combination of technologies that control on-off functions is selectable in the field by operating controls on unit.

1. Sensitivity Adjustment: Separate for each sensing technology.
2. Detector Sensitivity: Detect occurrences of 6-inch- (150-mm-) minimum movement of any portion of a human body that presents a target of not less than 36 sq. in. (232 sq. cm), and detect a person of average size and weight moving not less than 12 inches (305 mm) in either a horizontal or a vertical manner at an approximate speed of 12 inches/s (305 mm/s).

3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.
4. Detection Coverage (Room, Wall Mounted): Detect occupancy anywhere within a 180-degree pattern centered on the sensor over an area of 2000 square feet (220 square meters) when mounted 48 inches (1200 mm) above finished floor.

1.9 DIGITAL TIMER LIGHT SWITCH

A. Description: Combination digital timer and conventional switch lighting control unit. Switchbox-mounted, backlit LCD display, with selectable time interval in 10 minute increments.

1. Rated 960 W at 120-V ac for tungsten lighting, 10 A at 120-V ac or 10 amps at 277-V ac for ballast or LED, and 1/4 horsepower at 120-V ac.
2. Integral relay for connection to BAS.
3. Voltage: Match the circuit voltage.
4. Color: White
5. Faceplate: Color matched to switch.

1.10 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 22 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 16 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

1.11 EXAMINATION

A. Examine lighting control devices before installation. Reject lighting control devices that are wet, moisture damaged, or mold damaged.

B. Examine walls and ceilings for suitable conditions where lighting control devices will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

1.12 SENSOR INSTALLATION

A. Comply with NECA 1.

B. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression systems, and partition assemblies.

C. Install and aim sensors in locations to achieve not less than 90-percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

1.13 CONTACTOR INSTALLATION

A. Comply with NECA 1.

B. Mount electrically held lighting contactors with elastomeric isolator pads to eliminate structure-borne vibration unless contactors are installed in an enclosure with factory-installed vibration isolators.

1.14 WIRING INSTALLATION

A. Comply with NECA 1.

B. Wiring Method: Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size is 1/2 inch (13 mm).

C. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.

D. Size conductors according to lighting control device manufacturer's written instructions unless otherwise indicated.

E. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

1.15 IDENTIFICATION

A. Identify components and power and control wiring according to Section 260553 "Identification for Electrical Systems."

1. Identify controlled circuits in lighting contactors.
2. Identify circuits or luminaires controlled by photoelectric and occupancy sensors at each sensor.

B. Label time switches and contactors with a unique designation.

1.16 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Operational Test: After installing time switches and sensors, and after electrical circuitry has been energized, start units to confirm proper unit operation.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Lighting control devices will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

1.17 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting lighting control devices to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

1. For occupancy and motion sensors, verify operation at outer limits of detector range. Set time delay to suit Owner's operations.
2. For daylighting controls, adjust set points and deadband controls to suit Owner's operations.
3. Align high-bay occupancy sensors using manufacturer's laser aiming tool.

1.18 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.

B. 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 and access the system and to upgrade computer equipment if necessary.

1.19 DEMONSTRATION

A. Coordinate demonstration of products specified in this Section with demonstration requirements for low-voltage, programmable lighting control systems specified in Section 260943.16 "Addressable-Luminaire Lighting Controls" and Section 260943.23 "Relay-Based Lighting Controls."

B. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices.

END OF SECTION 260923

SECTION 261219 - PAD-MOUNTED, LIQUID-FILLED, MEDIUM-VOLTAGE TRANSFORMERS

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 pad-mounted, liquid-filled, medium-voltage distribution transformers, with primary and secondary bushings within or without air-terminal enclosures.

1.3 DEFINITIONS

A. BIL: Basic Impulse Insulation Level.

B. Bushing: An insulating structure including a central conductor, or providing a central passage for a conductor, with provision for mounting on a barrier, conducting or otherwise, for the purpose of insulating the conductor from the barrier and conducting current from one side of the barrier to the other.

C. Bushing Elbow: An insulated device used to connect insulated conductors to separable insulated connectors on dead-front, pad-mounted transformers and to provide a fully insulated connection. This is also called an "elbow connector."

D. Bushing Insert: That component of a separable insulated connector that is inserted into a bushing well to complete a dead-front, load break or nonload break, separable insulated connector (bushing).

E. Bushing Well: A component of a separable insulated connector, either permanently welded or clamped to an enclosure wall or barrier, having a cavity that receives a replaceable component (bushing insert) to complete the separable insulated connector (bushing).

F. Elbow Connector: See "bushing elbow" above.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, and furnished specialties and accessories.

B. Shop Drawings: For pad-mounted, liquid-filled, medium-voltage transformers.

1. Include plans and elevations showing major components and features.

a. Include a plan view and cross section of equipment base, showing clearances, required workspace, and locations of penetrations for grounding and conduits.

2. Include details of equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include single-line diagram.
4. Include list of materials.
5. Include nameplate data.
6. Manufacturer's published time-current curves of the transformer high-voltage fuses, with transformer damage curve, inrush curve, and thru fault current indicated.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Seismic Qualification Certificates: For transformer assembly, 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. Product Certificates: For transformers, signed by product manufacturer.

D. Source quality-control reports.

E. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For transformer and accessories to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.8 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 IEEE C2.

C. Comply with IEEE C57.12.00.

1.9 PERFORMANCE REQUIREMENTS

A. Seismic Performance: The 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. Component Importance Factor: 1.5.
3. Component Amplification Factor: 2.5.
4. Component Response Modification Factor: 6.0.

B. Windings Material: Copper.

C. Surge Arresters: Comply with IEEE C62.11, Distribution Class; metal-oxide-varistor type, fully shielded, separable-elbow type, suitable for plugging into the inserts provided in the high-voltage section of the transformer. Connected in each phase of incoming circuit and ahead of any disconnecting device.

D. Winding Connections: The connection of windings and terminal markings shall comply with IEEE C57.12.70.

E. Efficiency: Comply with 10 CFR 431, Subpart K.

F. Insulation: Transformer kVA rating shall be as follows: The average winding temperature rise above a 30 deg C ambient temperature shall not exceed 65 deg C and 80 deg C hottest-spot temperature rise at rated kVA when tested according to IEEE C57.12.90, using combination of connections and taps that give the highest average winding temperature rise.

G. Tap Changer: External handle, for de-energized operation.

H. Tank: Sealed, with welded-on cover. Designed to withstand internal pressure of not less than 7 psi (50 kPa) without permanent distortion and 15 psig (104 kPa) without rupture. Comply with IEEE C57.12.36.

I. Enclosure Integrity: Comply with IEEE C57.12.28 for pad-mounted enclosures that contain energized electrical equipment in excess of 600 V that may be exposed to the public.

J. Mounting: An integral skid mounting frame, suitable to allow skidding or rolling of transformer in any direction, and with provision for anchoring frame to pad.

K. Insulating Liquids:

1. Less-Flammable Liquids:

a. Edible-Seed-Oil-Based Dielectric: Listed and labeled by an NRTL as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D 92 and FM Approved. Liquid shall be biodegradable and nontoxic, having passed the Organization for Economic Co-operation and Development G.L.203 with zero mortality, and shall be certified by the U.S. Environmental Protection Agency as biodegradable, meeting Environmental Technology Verification requirements. Fluid shall be Envriotemp FR3 or approved equal.

L. Sound level shall comply with NEMA TR 1 requirements.

M. Corrosion Protection:

1. Transformer coating system shall be factory applied, complying with requirements of IEEE C57.12.28, in color selected by Architect.

1.10 THREE-PHASE TRANSFORMERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ABB.
2. Cooper Industries, Inc.
3. Eaton.

B. Description:

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 application.
2. Comply with IEEE C57.12.26.
3. FM Approved.

C. Compartment Construction:

1. Double-Compartment Construction: Individual compartments for high- and low-voltage sections, formed by steel isolating barriers that extend full height and depth of compartments, with hinged, lift-off doors and three-point latching, with a stop in the open position and provision for padlocking.

D. Primary Fusing: Designed and rated to provide thermal protection of transformer by sensing overcurrent and high liquid temperature., and as required for FM Approved transformer.

1. 150-kV BIL current-limiting fuses, conforming to requirements of IEEE C37.47.
2. Interrupting Rating: 50,000 rms A symmetrical at system voltage.
3. Fuse Assembly: Bayonet-type, liquid-immersed, expulsion fuses in series with liquid-immersed, partial-range, current-limiting fuses. Bayonet fuse shall sense both high currents and high oil temperature to provide thermal protection to the transformer. Connect current-limiting fuses ahead of radial-feed load-break switch.
4. Provide bayonet fuse assembly with an oil retention valve and an external drip shield inside the housing to eliminate or minimize oil spills. Valve shall close when fuse holder is removed and an external drip shield is installed.
5. Provide a conspicuously displayed warning adjacent to bayonet fuse(s), cautioning against removing or inserting fuses unless transformer has been de-energized and tank pressure has been released.

E. High-Voltage Section: Dead-front design.

1. To connect primary cable, use separable insulated connectors; coordinated with and complying with requirements of Section 260513 "Medium-Voltage Cables." Bushings shall be one-piece units, with ampere and BIL ratings the same as connectors.
2. Bushing inserts:
    a. Conform to the requirements of IEEE 386.
    b. Rated at 200 A, with voltage class matching connectors. Provide a parking stand near each bushing well.
3. Bushing wells configured for loop-feed application.
    a. Provide elbow connected surge arrestors on the feed through bushing wells.
4. Access to liquid-immersed fuses.
5. Tap-changer operator.
6. Load-Break Switch:
    a. Loop-feed sectionalizing switches, using three two-position, liquid-immersed-type switches for closed transition loop-feed and sectionalizing operation. Voltage class and BIL shall match that of separable connectors, with a continuous current rating and load-break rating of 200 amperes, and a make-and-latch rating of 12 kA rms symmetrical. Switch operation shall be as follows:
        1) Position I: Line A connected to line B and both lines connected to the transformer.
        2) Position II: Transformer connected to line A only.
        3) Position III: Transformer connected to line B only.
        4) Position IV: Transformer disconnected and line A not connected to line B.
        5) Position V: Transformer disconnected and line A connected to line B.
7. Ground pad.

F. Low-Voltage Section:

1. Bushings with spade terminals drilled for terminating the number of conductors indicated on the Drawings, and the lugs that comply with requirements of Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

G. Capacities and Characteristics:

1. Taps: Comply with IEEE C57.12.26 requirements.
2. Transformer BIL (kV): 95.
3. Minimum Tested Impedance (Percent at 85 deg C): 5.75.
4. Comply with UL listing requirements for combination classification and listing for transformer and less-flammable insulating liquid.

H. Transformer Accessories:

1. Drain and filter connection.
2. Filling and top filter press connections.
3. Pressure-vacuum gauge.
4. Dial-type analog thermometer with alarm contacts.
5. Magnetic liquid level indicator with high and low alarm contacts.
6. Automatically resetting pressure-relief device. Device flow shall be as recommended by manufacturer.
7. Stainless-steel ground connection pads.
8. Machine-engraved nameplate, made of anodized aluminum or stainless steel.
9. Sudden pressure relay for remote alarm or trip when internal transformer pressure rises at field-set rate. Provide with seal-in delay.
10. Exterior accessible oil sample port.

1.11 SERVICE CONDITIONS

A. Transformers shall be suitable for operation under service conditions specified as usual service conditions in IEEE C57.12.00, except for the following:

1. Altitudes above 7400 feet.
2. Cooling air temperature exceeds limits.
3. Excessive load current harmonic factor.
4. Operation above rated voltage or below rated frequency.
5. Exposure to explosive environments.
6. Exposure to fumes, vapors, or dust.
7. Exposure to hot and humid climate or to excessive moisture, including steam, salt spray, and dripping water.
8. Exposure to seismic shock or to abnormal vibration, shock, or tilting.
9. Exposure to excessively high or low temperatures.
10. Unusual transportation or storage conditions.
11. Unusual grounding resistance conditions.

1.12 WARNING LABELS AND SIGNS

A. Comply with requirements for labels and signs specified in Section 260553 "Identification for Electrical Systems."

1. High-Voltage Warning Label: Provide self-adhesive warning signs on outside of high-voltage compartment door(s). Sign legend shall be "DANGER HIGH VOLTAGE" printed in two lines of nominal 2-inch-high letters. The word "DANGER" shall be in white letters on a red background and the words "HIGH VOLTAGE" shall be in black letters on a white background.
2. Arc Flash Warning Label: Provide self-adhesive warning signs on outside of high-voltage compartment door(s), warning of potential electrical arc flash hazards and appropriate personal protective equipment required.

1.13 SOURCE QUALITY CONTROL

A. Provide manufacturer's certificate that the transformer design tests comply with IEEE C57.12.90.

1. Perform the following factory-certified routine tests on each transformer for this Project:

    a. Resistance.
    b. Turns ratio, polarity, and phase relation.
    c. Transformer no-load losses and excitation current at 100 percent of ratings.
    d. Transformer impedance voltage and load loss.
    e. Operation of all devices.
    f. Lightning impulse.
    g. Low frequency.
    h. Leak.
    i. Transformer no-load losses and excitation current at 110 percent of ratings.
    j. Insulation power factor.
    k. Applied potential, except that this test is not required for single-phase transformers or for three-phase Y-Y-connected transformers.
    l. Induced potential.
    m. Resistance measurements of all windings on rated voltage connection and at tap extreme connections.
    n. Ratios on rated voltage connection and at tap extreme connections.
    o. Polarity and phase relation on rated voltage connection.
    p. No-load loss at rated voltage on rated voltage connection.
    q. Exciting current at rated voltage on rated voltage connection.
    r. Impedance.

1.14 EXAMINATION

A. Examine pad-mounted, liquid-filled, medium-voltage transformers upon delivery.

1. Upon delivery of transformers and prior to unloading, inspect equipment for any damage that may have occurred during shipment or storage.
2. Verify that tie rods and chains are undamaged and tight, and that all blocking and bracing is tight. Verify that there is no evidence of load shifting in transit, and that readings from transportation shock recorders, if equipped, are within manufacturer's recommendations.

3. Verify that there is no indication of external damage and no dents or scratches in doors and sill, tank walls, radiators and fins, or termination provisions.
4. Verify that there is no evidence of insulating-liquid leakage on transformer surfaces, at weld seams, on high- or low-voltage bushing parts, and at transformer base.
5. Verify that there is positive pressure or vacuum on tank. Check pressure gauge; it is required to read other than zero.
6. Compare transformers and accessories received with bill of materials to verify that shipment is complete. Verify that transformers and accessories conform with manufacturer's quotation and shop drawings. If shipment is incomplete or does not comply with Project requirements, notify manufacturer in writing immediately.
7. Verify presence of polychlorinated biphenyl content labeling.
8. Unload transformers carefully, observing all packing label warnings and handling instructions.
9. Open termination compartment doors and inspect components for damage or displaced parts, loose or broken connections, cracked or chipped insulators, bent mounting flanges, dirt or foreign material, and water or moisture.

B. Handling:

1. Handle transformers carefully, in accordance with manufacturer recommendations, to avoid damage to enclosure, termination compartments, base, frame, tank, and internal components. Do not subject transformers to impact, jolting, jarring, or rough handling.
2. Protect transformer termination compartments against entrance of dust, rain, and snow.
3. Transport transformers upright, to avoid internal stresses on core and coil mounting assembly and to prevent trapping air in windings. Do not tilt or tip transformers.
4. Verify that transformer weights are within rated capacity of handling equipment.
5. Use only manufacturer-recommended points for lifting, jacking, and pulling. Use all lifting lugs when lifting transformers.
6. Use jacks only at corners of tank base plate.
7. Use nylon straps of same length to balance and distribute weight when handling transformers with a crane.
8. Use spreaders or a lifting beam to obtain a vertical lift and to protect transformer from straps bearing against enclosure. Lifting cable pull angles may not be greater than 15 degrees from vertical.
9. Exercise care not to damage tank base structure when handling transformer using skids or rollers. Use skids to distribute stresses over tank base when using rollers under large transformers.

C. Storage:

1. Store transformers in accordance with manufacturer's recommendations.
2. Transformers may be stored outdoors. If possible, store transformers at final installation locations on concrete pads. If dry concrete surfaces are unavailable, use pallets of adequate strength to protect transformers from direct contact with ground. Ensure transformer is level.
3. Ensure that transformer storage location is clean and protected from severe conditions. Protect transformers from dirt, water, contamination, and physical

damage. Do not store transformers in presence of corrosive or explosive gases. Protect transformers from weather when stored for more than three months.

4. Store transformers with compartment doors closed.
5. Regularly inspect transformers while in storage and maintain documentation of storage conditions, noting any discrepancies or adverse conditions. Verify that an effective pressure seal is maintained using pressure gauges. Visually check for insulating-liquid leaks and rust spots.

D. Examine areas and space conditions for compliance with requirements for pad-mounted, liquid-filled, medium-voltage transformers and other conditions affecting performance of the Work.

E. Examine roughing-in of conduits and grounding systems to verify the following:

1. Wiring entries comply with layout requirements.
2. Entries are within conduit-entry tolerances specified by manufacturer, and no feeders will cross section barriers to reach load or line lugs.

F. Examine concrete bases for suitable conditions for transformer installation.

G. Pre-Installation Checks:

1. Verify removal of any shipping bracing after placement.
2. Remove a sample of insulating liquid according to ASTM D 923. Insulating-liquid values shall comply with NETA ATS, Table 100.4. Sample shall be tested for the following:

    a. Dielectric Breakdown Voltage: ASTM D 877 or ASTM D 1816.
    b. Acid Neutralization Number: ASTM D 974.
    c. Specific Gravity: ASTM D 1298.
    d. Interfacial Tension: ASTM D 971.
    e. Color: ASTM D 1500.
    f. Visual Condition: ASTM D 1524.
    g. Water in Insulating Liquids: Comply with ASTM D 1533.
    h. Power Factor or Dissipation Factor: ASTM D 924.

H. Verify that ground connections are in place and that requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at transformer location.

I. Proceed with installation only after unsatisfactory conditions have been corrected.

1.15 INSTALLATION

A. Install transformers on pre-cast concrete box pad specifically designed and approved for the transformer. The underground box portion of the pad shall allow for routing of cables. Install box pad per manufacturer’s requirements.

B. Transformer shall be installed level and plumb and shall tilt less than 1.5 degrees while energized.

C. Comply with requirements for vibration isolation and seismic control devices specified in Section 260529 "Hangers and Supports for Electrical Systems" and Section 260548.16 "Seismic Controls for Electrical Systems."

D. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and IEEE C2.

1.16 CONNECTIONS

A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

1. For counterpoise, use tinned bare copper cable not smaller than No. 4/0 AWG, buried not less than 30 inches below grade interconnecting the grounding electrodes. Bond surge arrester and neutrals directly to transformer enclosure and then to grounding electrode system with bare copper conductors, sized as shown. Keep lead lengths as short as practicable, with no kinks or sharp bends.
2. Fence and equipment connections shall not be smaller than No. 4 AWG. Ground fence at each gate post and corner post and at intervals not exceeding 10 ft. Bond each gate section to fence post using 1/8 by 1 inch tinned flexible braided copper strap and clamps.
3. Make joints in grounding conductors and loops by exothermic weld or compression connector.
4. Terminate all grounding and bonding conductors on a common equipment grounding terminal on transformer enclosure.
5. Complete transformer tank grounding and lightning arrester connections prior to making any other electrical connections.

B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

1. Maintain air clearances between energized live parts and between live parts and ground for exposed connections in accordance with manufacturer recommendations.
2. Bundle associated phase, neutral, and equipment grounding conductors together within transformer enclosure. Arrange conductors such that there is not excessive strain that could cause loose connections. Allow adequate slack for expansion and contraction of conductors.

C. Terminate medium-voltage cables in incoming section of transformers according to Section 260513 "Medium-Voltage Cables."

1.17 SIGNS AND LABELS

A. Comply with installation requirements for labels and signs specified in Section 260553 "Identification for Electrical Systems."

B. Install warning signs as required to comply with 29 CFR 1910.269.

1.18 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

1. General Field-Testing Requirements:

a. Comply with provisions of NFPA 70B Ch. "Testing and Test Methods."
b. Perform each visual and mechanical inspection and electrical test. Certify compliance with test parameters.
c. After installing transformer but before primary is energized, verify that grounding system at the transformer is tested at specified value or less.
d. After installing transformer and after electrical circuitry has been energized, test for compliance with requirements.
e. Visual and Mechanical Inspection:

1) Verify equipment nameplate data complies with Contract Documents.
2) Inspect bolted electrical connections for high resistance using one of the following two methods:

a) Use a low-resistance ohmmeter to 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.
b) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels shall be according to manufacturer's published data. In absence of manufacturer's published data, use NETA ATS, Table 100.12.

f. Remove and replace malfunctioning units and retest.
g. Prepare test and inspection reports. Record as-left set points of all adjustable devices.

2. Medium-Voltage Surge Arrester Field Tests:

a. Visual and Mechanical Inspection:

1) Inspect physical and mechanical condition.
2) Verify arresters are clean.
3) Verify that ground lead on each device is individually attached to a ground bus or ground electrode.

b. Electrical Test:

1) Perform an insulation-resistance test on each arrester, phase terminal-to-ground. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Replace units that fail to comply with recommended minimum insulation resistance listed in that table.
2) Perform a watts-loss test. Evaluate watts-loss values by comparison with similar units and test equipment manufacturer's published data.

3. Liquid-Filled Transformer Field Tests:

a. Visual and Mechanical Inspection:

1) Test dew point of tank gases if applicable.
2) Inspect anchorage, alignment, and grounding.
3) Verify bushings are clean.
4) Verify that alarm, control, and trip settings on temperature and level indicators are set and operate within manufacturer's recommended settings.
5) Verify that liquid level in tanks is within manufacturer's published tolerances.
6) Perform specific inspections and mechanical tests recommended by manufacturer.
7) Verify presence of transformer surge arresters and that their ratings are as specified.
8) Verify that as-left tap connections are as specified.

b. Electrical Tests:

1) 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.
2) Perform power-factor or dissipation-factor tests on all windings according to test equipment manufacturer's published data. Maximum winding insulation power-factor/dissipation-factor values shall be according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.3.
3) Measure core insulation resistance at 500-V dc if the core is insulated and the core ground strap is removable. Core insulation-resistance values shall not be less than 1 megohm at 500-V dc.
4) Perform a power-factor or dissipation-factor tip-up test on windings greater than 2.5 kV.
5) Perform turns-ratio tests at tap positions. Turns-ratio test results shall not deviate by more than one-half percent from either adjacent coils or calculated ratio. If test fails, replace transformer.
6) Perform an excitation-current test on each phase. The typical excitation-current test data pattern for a three-legged core transformer is two similar current readings and one lower current reading. Investigate and correct if test shows a different pattern.
7) Measure resistance of each winding at each tap connection, and record temperature-corrected winding-resistance values in the Operations and Maintenance Manual.
8) Perform an applied-voltage test on high- and low-voltage windings-to-ground. Comply with IEEE C57.12.91, Sections 10.2 and 10.9. This test is not required for single-phase transformers and for three-phase Y-Y-connected transformers.
9) Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.

10) Remove a sample of insulating liquid according to ASTM D 923, and perform dissolved-gas analysis according to IEEE C57.104 or ASTM D 3612.

1.19 FOLLOW-UP SERVICE

A. Voltage Monitoring and Adjusting: After Substantial Completion, if requested by Owner, but not more than six months after Final Acceptance, perform the following voltage monitoring:

1. During a period of normal load cycles as evaluated by Owner, perform seven days of three-phase voltage recording at the outgoing section of each transformer. Use voltmeters with calibration traceable to the National Institute of Science and Technology standards and with a chart speed of not less than 1 inch per hour. Voltage unbalance greater than 1 percent between phases, or deviation of any phase voltage from the nominal value by more than plus or minus 5 percent during test period, is unacceptable.
2. Corrective Action: If test results are unacceptable, perform the following corrective action, as appropriate:
    a. Adjust transformer taps.
    b. Prepare written request for voltage adjustment by electric utility.
3. Retests: Repeat monitoring, after corrective action is performed, until satisfactory results are obtained.
4. Report:
    a. Prepare a written report covering monitoring performed and corrective action taken.

B. Infrared Inspection: Perform survey during periods of maximum possible loading. Remove all necessary covers prior to inspection.

1. After Substantial Completion, but not more than 60 days after Final Acceptance, perform infrared inspection of transformer's electrical power connections.
2. Instrument: Inspect distribution systems with imaging equipment capable of detecting a minimum temperature difference of 1?C at 30?C.
3. Record of Infrared Inspection: Prepare a certified report that identifies testing technician and equipment used, and lists results as follows:
    a. Description of equipment to be tested.
    b. Discrepancies.
    c. Temperature difference between area of concern and reference area.
    d. Probable cause of temperature difference.
    e. Areas inspected. Identify inaccessible and unobservable areas and equipment.
    f. Identify load conditions at time of inspection.
    g. Provide photographs and thermograms of deficient area.
4. Act on inspection results according to recommendations of NETA ATS, Table 100.18. Correct possible and probable deficiencies as soon as Owner's operations permit. Retest until deficiencies are corrected.

1.20 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain systems.

END OF SECTION 261219

SECTION 262200 - LOW-VOLTAGE TRANSFORMERS

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 rated 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. Seismic Qualification 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.

B. Qualification Data: For testing agency.

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 Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.7 DELIVERY, STORAGE, AND HANDLING

A. 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.

1.8 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton.
2. SIEMENS Industry, Inc.; Energy Management Division.
3. Square D; by Schneider Electric.

B. Source Limitations: Obtain each transformer type from single source from single manufacturer.

1.9 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.

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. Transformers Rated 15 kVA and Larger: Comply with NEMA TP 1 energy-efficiency levels as verified by testing according to NEMA TP 2.

D. Cores: Electrical grade, non-aging silicon steel with high permeability and low hysteresis losses.

E. Coils: Continuous windings without splices except for taps.

1. Internal Coil Connections: Brazed or pressure type.
2. Coil Material: Copper or aluminum

F. Encapsulation: Transformers smaller than 30 kVA shall have core and coils completely resin encapsulated.

G. 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.

1.10 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 specified in Section 260548.16 "Seismic Controls for Electrical Systems."

C. Cores: One leg per phase.

D. Enclosure: Ventilated.

1. NEMA 250, Type 2: Core and coil shall be encapsulated within resin compound[ ] to seal out moisture and air.
2. KVA Ratings: Based on convection cooling only and not relying on auxiliary fans.

E. Transformer Enclosure Finish: Comply with NEMA 250.

1. Finish Color: Gray.

F. Taps for Transformers 3 kVA and Smaller: None.

G. Taps for Transformers 7.5 to 24 kVA: One 5 percent tap above and one 5 percent tap below normal full capacity.

H. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity.

I. Insulation Class, Smaller than 30 kVA: 185 deg C, UL-component-recognized insulation system with a maximum of 115-deg C rise above 40-deg C ambient temperature.

J. 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.
2. Indicate value of K-factor on transformer nameplate.

3. Unit shall meet requirements of NEMA TP 1 when tested according to NEMA TP 2 with a K-factor equal to one.

K. Electrostatic Shielding: Each winding shall have an independent, single, full-width copper electrostatic shield arranged to minimize interwinding 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.

L. Neutral: Rated 200 percent of full load current for K-factor rated transformers.

M. Wall Brackets: Manufacturer's standard brackets.

N. Low-Sound-Level Requirements: Maximum sound levels when factory tested according to IEEE C57.12.91, as follows:

1. 9 kVA and Less
2. 30 to 50 kVA
3. 51 to 150 kVA
4. 151 to 300 kVA
5. 301 to 500 kVA
6. 501 to 750 kVA
7. 751 to 1000 kVA
8. 1001 to 1500 kVA

1.11 IDENTIFICATION DEVICES

A. Nameplates: Engraved, laminated-plastic or metal nameplate for each distribution transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Section 260553 "Identification for Electrical Systems."

1.12 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 the rated voltage connections and at all tap connections.
2. Ratio tests at the rated voltage connections and at all tap connections.
3. Phase relation and polarity tests at the rated voltage connections.
4. No load losses, and excitation current and rated voltage at the rated voltage connections.
5. Impedance and load losses at rated current and rated frequency at the 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 prototype sound-level tests on production-line products.

1.13 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 260526 "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.

1.14 INSTALLATION

A. Install wall-mounted transformers level and plumb with wall brackets fabricated by transformer manufacturer.

1. Coordinate installation of wall-mounted and structure-hanging supports with actual transformer provided.
2. Brace wall-mounted transformers as specified in Section 260548.16 "Seismic Controls for Electrical Systems."

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 033000 "Cast-in-Place Concrete" and anchor floor-mounted transformers according to manufacturer's written instructions, seismic codes applicable to Project, and requirements in Section 260529 "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.

1.15 CONNECTIONS

A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Section 260519 "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.

1.16 FIELD QUALITY CONTROL

A. Testing Agency: Owner will 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 tests and inspections.

D. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS for dry-type, air-cooled, low-voltage transformers. Certify compliance with test parameters.

E. Remove and replace units that do not pass tests or inspections and retest as specified above.

F. 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.

G. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

1.17 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. Connect buck-boost transformers to provide nameplate voltage of equipment being served, plus or minus 5 percent, at secondary terminals.

C. Output Settings Report: Prepare a written report recording output voltages and tap settings.

1.18 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION 262200

SECTION 262413 - SWITCHBOARDS

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 260574 "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 Installer, 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 017823 "Operation and Maintenance Data," 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 Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

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 install temporary electric heating (250 W per section) to prevent condensation.

C. Handle and prepare switchboards for installation according to NECA 400.

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: Not exceeding 7400 feet.

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 agrees to repair or replace switchboard enclosures, buswork, overcurrent protective devices, accessories, and factory installed interconnection wiring that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Three years from date of Substantial Completion.

B. 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.

1.13 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."

1.14 SWITCHBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton.
2. SIEMENS Industry, Inc.; Energy Management Division.
3. Square D; by Schneider Electric.

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. Nominal System Voltage: As indicated.

J. Main-Bus Continuous: As indicated.

K. Seismic Requirements: Fabricate and test switchboards according to IEEE 344 to withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems."

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."

L. Indoor Enclosures: Steel, NEMA 250, Type 1.

M. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.

1. Power for space heaters, ventilation, lighting, and receptacle provided by a remote source.

N. Barriers: Between adjacent switchboard sections.

O. Insulation and isolation for main bus of main section and main and vertical buses of feeder sections.

P. 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.

Q. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.

R. Removable, Hinged Rear Doors and Compartment Covers: Secured by captive thumb screws, for access to rear interior of switchboard.

S. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.

T. 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. Copper feeder circuit-breaker line connections.
4. Load Terminals: Insulated, rigidly braced, runback bus extensions, of same material as through buses, equipped with mechanical connectors for outgoing circuit conductors. Provide load terminals for future circuit-breaker positions at full-ampere rating of circuit-breaker position.
5. Ground Bus: 1/4-by-2-inch,-hard-drawn copper of 98 percent conductivity, equipped with mechanical connectors for feeder and branch-circuit ground conductors.
6. 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.
7. 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.

8. Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with mechanical connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.
9. Isolation Barrier Access Provisions: Permit checking of bus-bolt tightness.

U. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

V. 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.

W. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components including instruments and instrument transformers.

1.15 SURGE PROTECTION DEVICES

A. SPDs: Comply with UL 1449, Type 1.

B. 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. Surge counter.

C. SCCR: Equal or exceed 100 kA.

D. Nominal Rating: 20 kA.

1.16 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.

1. 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.

2. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).

3. MCCB Features and Accessories:

a. Standard frame sizes, trip ratings, and number of poles.
b. Lugs: Mechanical 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. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
f. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

1.17 INSTRUMENTATION

A. Instrument Transformers: NEMA EI 21.1, and the following:

1. Potential Transformers: NEMA EI 21.1; 120 V, 60 Hz, single 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. Meter shall be Schneider Electric model indicated. Meter shall be interconnected into the electrical power metering system, refer to section 26093 for additional requirements.
2. 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.

3. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.

1.18 CONTROL POWER

A. Control Circuits: 120-V ac, supplied through secondary disconnecting devices from control-power transformer.

B. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.

C. 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.

1.19 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 requirements in Section 260548.16 "Seismic Controls for Electrical Systems" or manufacturer's instructions.

1.20 IDENTIFICATION

A. 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.

B. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.

1.21 EXAMINATION

A. Receive, inspect, handle, and store switchboards according to NECA 400.

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.

1.22 INSTALLATION

A. Install switchboards and accessories according to NECA 400.

B. Equipment Mounting: Install switchboards on concrete base, 4-inch nominal thickness. Comply with requirements for concrete base specified in Section 033000 "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 specified in Section 260548.16 "Seismic Controls for Electrical Systems."

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.

1.23 CONNECTIONS

A. Comply with requirements for terminating feeder bus specified in Section 262500 "Enclosed Bus Assemblies." Drawings indicate general arrangement of bus, fittings, and specialties.

B. Comply with requirements for terminating cable trays specified in Section 260536 "Cable Trays for Electrical Systems." Drawings indicate general arrangement of cable trays, fittings, and specialties.

C. Bond conduits entering underneath the switchboard to the equipment ground bus with a bonding conductor sized per NFPA 70.

D. Support and secure conductors within the switchboard according to NFPA 70.

E. Extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.

1.24 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Section 260553 "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 260553 "Identification for Electrical Systems."

1.25 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. 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 and rear 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.

D. Switchboard will be considered defective if it does not pass tests and inspections.

E. 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.

1.26 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 260573 "Overcurrent Protective Device Coordination Study."

1.27 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.

1.28 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 262413

SECTION 262416 - PANELBOARD

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.

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 017823 "Operation and Maintenance Data," 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 NECA 407 and 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.
    b. Altitude: Not exceeding 7400 feet.

B. Service Conditions: NEMA PB 1, usual service conditions, as follows:

1. Ambient temperatures within limits specified.
2. Altitude not exceeding 7400 feet.

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.

1.12 PANELBOARDS 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 and Wash-Down Areas: NEMA 250, Type 4X, stainless steel.
    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: 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. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover. Trims shall cover all live parts and shall have no exposed hardware.
5. Skirt for Surface-Mounted Panelboards: Same gage and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor, where indicated.
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: Steel and 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: Galvanized steel.

G. Incoming Mains:

1. Location: As required by field conditions.
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. 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.
5. 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.
6. 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: Mechanical type, with a lug on the neutral bar for each pole in the panelboard.
5. Ground Lugs and Bus-Configured Terminators: Mechanical type, with a lug on the bar for each pole in the panelboard.
6. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
7. Subfeed (Double) Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
8. Gutter-Tap Lugs: Mechanical type suitable for use with conductor material and with matching insulating covers. Locate at same end of bus as incoming lugs or main device.

J. NRTL Label: Panelboards 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: 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.

1.13 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. Where indicated on the single line provide Surge Suppression: Factory installed as an integral part of indicated panelboards, complying with UL 1449 SPD. Provide SPD unit with features and ratings per specification 264313 requirements, except mounted integrally inside panel. Provide disconnecting means in panel for SPD. Provide integral overcurrent protection.”

1.14 POWER PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton.
2. SIEMENS Industry, Inc.; Energy Management Division.
3. Square D; by Schneider Electric.

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: As indicated

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.

1.15 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton.
2. SIEMENS Industry, Inc.; Energy Management Division.
3. Square D; by Schneider Electric.

B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

C. Mains: Circuit breaker or lugs only as indicated.

D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

E. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

F. Doors: Door-in-door construction with concealed hinges; secured with multipoint latch with tumbler lock; keyed alike. Outer door shall permit full access to the panel interior. Inner door shall permit access to breaker operating handles and labeling, but current carrying terminals and bus shall remain concealed.

1.16 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. 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. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).
4. GFEP Circuit Breakers: Class B ground-fault protection (30-mA trip).
5. Subfeed Circuit Breakers: Vertically mounted.
6. 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: Mechanical 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: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
h. Rating Plugs: Three-pole breakers with ampere ratings greater than 150 amperes shall have interchangeable rating plugs or electronic adjustable trip units.
i. Alarm Switch: Single-pole, normally open contact that actuates only when circuit breaker trips.
j. Multipole units enclosed in a single housing with a single handle.
k. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.
l. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.

1.17 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.

1.18 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

1.19 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.

1.20 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) where floor mounted.. Comply with requirements for equipment bases and foundations specified in Section 033000 "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 specified in Section 260548.16 "Seismic Controls for Electrical Systems."

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 specified in Section 260548.16 "Seismic Controls for Electrical Systems."

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.

1.21 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; install warning signs complying with requirements in Section 260553 "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 260553 "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 260553 "Identification for Electrical Systems."

E. Install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems" identifying source of remote circuit.

1.22 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. Acceptance Testing Preparation:

1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

D. 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. Perform optional tests. 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.

E. Panelboards will be considered defective if they do not pass tests and inspections.

F. 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.

1.23 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 260573 "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.

1.24 PROTECTION

A. Temporary Heating: Prior to energizing panelboards, apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION 262416

SECTION 262726 - WIRING DEVICES

1.1 SUMMARY

A. Section Includes:

1. General-use switches, and dimmer switches.
2. General-grade duplex straight-blade receptacles.
3. Locking receptacles.
4. Pin-and-sleeve receptacles.
5. Special-purpose power outlet assemblies.
6. Connectors, cords, and plugs.

B. Related Requirements:

1. Section 260500 "Common Work Results for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260923 "Lighting Control Devices" for occupancy sensors, timers, control-voltage switches, and control-voltage dimmers.
3. Section 260943.23 "Relay-Based Lighting Controls" for network lighting control relay devices.

1.2 ACTION SUBMITTALS

A. Product Data:

1. Toggle switches.
2. Key lock switches.
3. Maintained-contact switches.
4. Momentary-contact switches.
5. Rocker switches.
6. Dimmer switches.
7. Single straight-blade receptacles
8. Duplex straight-blade receptacles.
9. Duplex straight-blade receptacles with integral switching means.
10. Receptacles with GFCI device.
11. Locking receptacles.
12. Pin-and-sleeve receptacles.
13. Spring-driven commercial/industrial-use cord reels.
14. Cord reels for use in hazardous locations.
15. Cord connectors.

B. Shop Drawings:

1. Wiring diagrams for duplex straight-blade receptacles with integral switching means.

C. Field Quality-Control Submittals:

1. Field quality-control reports.

1.3 INFORMATIONAL SUBMITTALS

A. Manufacturers' Instructions: Record copy of official installation and testing instructions issued to Installer by manufacturer for the following:

1. Dimmers.
2. Fan-speed controllers.
3. Single straight-blade receptacles.
4. Duplex straight-blade receptacles.
5. Duplex straight-blade receptacles with integral switching means.
6. Hospital-grade straight-blade receptacles.
7. Receptacles with AFCI device.
8. Receptacles with AFCI and GFCI devices.
9. Receptacles with GFCI device.
10. Locking receptacles.
11. Pin-and-sleeve receptacles.
12. Spring-driven commercial/industrial-use cord reels.
13. Cord reels for use in hazardous locations.

B. Sample warranties.

1.4 MAINTENANCE MATERIAL SUBMITTALS

A. Extra Stock Items: Furnish extra materials to Owner that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Extra Keys for Key Lock Switches: One of each kind.
2. SPD Receptacles: Equal to 10 percent of quantity installed for each kind specified, but no fewer than one unit.
3. Controlled Receptacles: Equal to 10 percent of quantity installed for each kind specified, but no fewer than one unit.
4. Cord Connectors: One of each kind.

B. Special Tools:

1. Proprietary equipment and software required to maintain, repair, adjust, or implement future changes to controlled receptacles.
2. Proprietary equipment required to maintain, repair, adjust, or implement future changes to cord connectors.

1.5 WARRANTY FOR DEVICES

A. Special Manufacturer Extended Warranty: Manufacturer warrants that devices perform in accordance with specified requirements and agrees to provide repair or replacement of devices that fail to perform as specified within extended warranty period.

1. Initial Warranty Period: One year from date of Substantial Completion; full coverage for labor, materials, and equipment.

1.6 WARRANTY FOR CORD REELS

A. Special Manufacturer Extended Warranty: Manufacturer warrants that components of cord-reel power outlet assemblies perform in accordance with specified requirements and agrees to provide repair or replacement of components that fail to perform as specified within extended warranty period.

1. Initial Warranty Period: One year from date of Substantial Completion; full coverage for labor, materials, and equipment.

1.7 GENERAL-USE SWITCHES, DIMMER SWITCHES.

A. Toggle Switch:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
c. Leviton Manufacturing Co., Inc.
d. Pass & Seymour; Legrand North America, LLC.

2. Regulatory Requirements:

a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

3. General Characteristics:

a. Reference Standards: UL CCN WMUZ and UL 20.

4. Options:

a. Device Color: As required by Architect.
b. Configuration:

1) General-duty, 120-277 V, 20 A, single pole, double pole, three way and four way.

5. Accessories:

    a. Cover Plate: 0.060 inch thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
    b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

B. Rocker Switch:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
    b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
    c. Leviton Manufacturing Co., Inc.
    d. Pass & Seymour; Legrand North America, LLC.

2. Regulatory Requirements:

    a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

3. General Characteristics:

    a. Reference Standards: UL CCN WMUZ and UL 20.

4. Options:

    a. Device Color: As required by Architect.
    b. Configuration:

        1) 120-277 V, 20 A.

5. Accessories:

    a. Cover Plate: 0.060 inch thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
    b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

C. Type I Dimmer Switch:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
    b. GE Lighting; General Electric Company.

c. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
d. Leviton Manufacturing Co., Inc.
e. Lutron Electronics Co., Inc.
f. Pass & Seymour; Legrand North America, LLC.

2. Regulatory Requirements:

a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

3. General Characteristics:

a. Reference Standards: UL CCN EOYX and UL 1472 Type I dimmer.

4. Options:

a. Device Color: As required by Architect
b. Switch Style: Push button.
c. Dimming Control Style: Slide.

5. Accessories:

a. Cover Plate: 0.060 inch thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

1.8 GENERAL-GRADE DUPLEX STRAIGHT-BLADE RECEPTACLES

A. Duplex Straight-Blade Receptacle:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
c. Leviton Manufacturing Co., Inc.
d. Pass & Seymour; Legrand North America, LLC.

2. Regulatory Requirements:

a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

3. General Characteristics:

a. Reference Standards: UL CCN RTRT and UL 498.

4. Options:

a. Device Color: As required by Architect.
b. Configuration:

1) Heavy-duty, NEMA 5-20R.

5. Accessories:

a. Cover Plate: 0.060 inch thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

B. Tamper-Resistant Duplex Straight-Blade Receptacle:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
c. Leviton Manufacturing Co., Inc.
d. Pass & Seymour; Legrand North America, LLC.

2. Regulatory Requirements:

a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

3. General Characteristics:

a. Reference Standards: UL CCN RTRT and UL 498.

4. Options:

a. Device Color: As required by Architect.
b. Configuration:

1) Heavy-duty, NEMA 5-20R.

5. Accessories:

a. Cover Plate: 0.060 inch thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.

b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

C. Wired Full-Controlled Duplex Straight-Blade Receptacle:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Hubbell Lighting; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
c. Pass & Seymour; Legrand North America, LLC.

2. Regulatory Requirements:

a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

3. General Characteristics:

a. Reference Standards: UL CCN RTXI and UL Subject 498B.

4. Options:

a. Device Color: As required by Architect
b. Configuration: NEMA 5-20R.

5. Accessories:

a. Cover Plate: 0.060 inch thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

D. Wired Half-Controlled Duplex Straight-Blade Receptacle:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Hubbell Lighting; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
c. Pass & Seymour; Legrand North America, LLC.

2. Regulatory Requirements:

a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

3. General Characteristics:

a. Reference Standards: UL CCN RTXI and UL Subject 498B.

4. Options:

a. Device Color: As required by Architect
b. Configuration: NEMA 5-20R.

5. Accessories:

a. Cover Plate: 0.060 inch thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

1.9 LOCKING RECEPTACLES

A. NEMA, 125 V, Locking Receptacle:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
c. Leviton Manufacturing Co., Inc.
d. Pass & Seymour; Legrand North America, LLC.

2. Regulatory Requirements:

a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

3. General Characteristics:

a. Reference Standards: UL CCN RTRT and UL 498.

4. Options:

a. Device Color: Black with yellow voltage indication on face.
b. Configuration: 2 pole, 3 wire, grounding, NEMA L5-20R, NEMA L5-30R.

B. NEMA, 250 V, Locking Receptacle:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
    b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
    c. Leviton Manufacturing Co., Inc.
    d. Pass & Seymour; Legrand North America, LLC.

2. Regulatory Requirements:

    a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

3. General Characteristics:

    a. Reference Standards: UL CCN RTRT and UL 498.

4. Options:

    a. Device Color: Black with blue voltage indication on face.
    b. Configuration:

        1) 2 pole, 3 wire, grounding, NEMA L6-15R, NEMA L6-20R, NEMA L6-30R.
        2) 3 pole, 4 wire, grounding, NEMA L15-20R, NEMA L15-30R.
        3) 4 pole, 5 wire, grounding, NEMA L21-20R, NEMA L21-30R.

1.10 PIN-AND-SLEEVE RECEPTACLES

A. C2 Series, 125/250 V, Pin-and-Sleeve Receptacles:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. ABB, Electrification Business.
    b. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
    c. Crouse-Hinds; brand of Eaton, Electrical Sector.
    d. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
    e. Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
    f. Leviton Manufacturing Co., Inc.
    g. Pass & Seymour; Legrand North America, LLC.

2. Regulatory Requirements:

    a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

3. General Characteristics:

    a. Reference Standards: UL CCN QLIW, UL 1682, and UL 1686.
    b. Series: UL 1686 C2 and IEC 60309-2 Series II.
    c. Voltage Rating: 125/250 V.

4. Options:

    a. Configuration: As indicated

B. C2 Series, 480 V, Pin-and-Sleeve Receptacles:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. ABB, Electrification Business.
    b. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
    c. Crouse-Hinds; brand of Eaton, Electrical Sector.
    d. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
    e. Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
    f. Leviton Manufacturing Co., Inc.
    g. Pass & Seymour; Legrand North America, LLC.

2. Regulatory Requirements:

    a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

3. General Characteristics:

    a. Reference Standards: UL CCN QLIW, UL 1682, and UL 1686.
    b. Series: UL 1686 C2 and IEC 60309-2 Series II.
    c. Voltage Rating: 480 V.

4. Options:

    a. Configuration: As indicated

1.11 SPECIAL-PURPOSE POWER OUTLET ASSEMBLIES

A. Ceiling-Mounted Power Outlet Cord Management Assembly:

1. Source Limitations: Obtain all components for each power outlet cord management assembly from single manufacturer.
2. Regulatory Requirements: Components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

3. General Characteristics: Provide the following specified products with fabricated power outlet cord management assembly:

    a. Cord Management System:

        1) Spring-driven commercial/industrial-use cord reel, No. 14 AWG conductors.
        2) Cord reel for use in Class I Group D hazardous location.

    b. Termination Fitting:

        1) Outdoor-use, watertight, sealed cord connectors.

B. Spring-Driven Commercial/Industrial-Use Cord Reel, No. 14 AWG Conductors.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Eaton.
    b. Ericson Manufacturing Company.
    c. Gleason Reel; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

2. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
3. General Characteristics:

    a. Reference Standards: UL CCN SBCV and UL 355.
    b. Spring take-up retraction mechanism.

4. Options:

    a. Electrical Rating with Cable: 600 V, 18 A.
    b. Color: Black.
    c. Enclosure Degree of Protection: Type 4.
    d. Ball stop.
    e. Pivot base.
    f. Spool Capacity:

        1) No. 14 AWG, two wires and equipment ground, 20 ft.
        2) No. 14 AWG, three wires and equipment ground, 20 ft.
        3) No. 14 AWG, five wires and equipment ground, 20 ft.

C. Spring-Driven Commercial/Industrial-Use Cord Reel, No. 12 AWG Conductors:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Appleton; Emerson Electric Co., Automation Solutions.
    b. Ericson Manufacturing Company.
    c. Gleason Reel; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

d. Reelcraft; Madison Industries.

2. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
3. General Characteristics:

a. Reference Standards: UL CCN SBCV and UL 355.
b. Spring take-up retraction mechanism.

4. Options:

a. Electrical Rating with Cable: 600 V, 20 A.
b. Color: Black.
c. Enclosure Degree of Protection: Type 4.
d. Ball stop.
e. Pivot base.
f. Spool Capacity:

1) No. 12 AWG, two wires and equipment ground, 20 ft.
2) No. 12 AWG, three wires and equipment ground, 20 ft.
3) No. 12 AWG, five wires and equipment ground, 20 ft.

D. Spring-Driven Cord Reel for Use in Class I Group D Hazardous Locations:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Appleton; Emerson Electric Co., Automation Solutions.
b. Conductix-Wampfler USA; Delachaux Group.
c. KH Industries, Inc.

2. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
3. General Characteristics:

a. Reference Standards: UL CCN SAOX and UL 355.
b. Spring take-up retraction mechanism.

4. Options:

a. Electrical Rating with Cable: 600 V, 20 A.
b. Color: Black.
c. Enclosure Degree of Protection: Type 4.
d. Ball stop.
e. Pivot base.
f. Spool Capacity:

1) No. 14 AWG, two wires and equipment ground, 20 ft.
2) No. 14 AWG, three wires and equipment ground, 20 ft.

3) No. 12 AWG, two wires and equipment ground, 20 ft.
4) No. 12 AWG, three wires and equipment ground, 20 ft.

1.12 CONNECTORS, CORDS, AND PLUGS

A. Outdoor-Use, Watertight, Sealed Cord Connector:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. Ericson Manufacturing Company.

2. Regulatory Requirements:

a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

3. General Characteristics:

a. Reference Standards: UL CCN AXUT and UL 498.

4. Options:

a. Configuration:

1) NEMA 5-15.
2) NEMA 5-20.
3) NEMA 6-15.
4) NEMA 6-20.
5) NEMA L5-15.
6) NEMA L5-20.
7) NEMA L5-30.
8) NEMA L6-15.
9) NEMA L6-20.
10) NEMA L6-30.
11) NEMA L7-15.
12) NEMA L7-20.
13) NEMA L7-30.
14) NEMA L14-20.
15) NEMA L14-30.
16) NEMA L15-20.
17) NEMA L15-30.
18) NEMA L16-20.
19) NEMA L16-30.
20) NEMA L17-30.
21) NEMA L18-30.

1.13 EXAMINATION

A. Receptacles:

1. Verify that receptacles to be procured and installed for Owner-furnished equipment are compatible with mating attachment plugs on equipment.

B. Cord Reels:

1. Examine roughing-in for cord reel mounting and power connections to verify actual locations of mounts and power connections before cord reel installation.
2. Examine walls, floors, and ceilings for suitable conditions where cord reel will be installed.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

1.14 INSTALLATION OF SWITCHES

A. Comply with manufacturer's instructions.

B. Reference Standards:

1. Unless more stringent requirements are specified in Contract Documents or manufacturers' instructions, comply with installation instructions in NECA NEIS 130.
2. Mounting Heights: Unless otherwise indicated in Contract Documents, comply with mounting heights recommended in NECA NEIS 1.
3. Consult Architect for resolution of conflicting requirements.

C. Identification:

1. Identify cover or cover plate for device with panelboard identification and circuit number in accordance with Section 260553 "Identification for Electrical Systems."

a. Mark cover or cover plate using hot, stamped, or engraved machine printing with black-filled lettering, and provide durable wire markers or tags inside device box or outlet box.
b. Healthcare Facilities: Distinctively identify covers or cover plates of device boxes and outlet boxes that are supplied from life safety and critical branch power supplies following facility's standard practice.

1.15 INSTALLATION OF STRAIGHT-BLADE RECEPTACLES

A. Comply with manufacturer's instructions.

B. Reference Standards:

1. Unless more stringent requirements are specified in Contract Documents or manufacturers' instructions, comply with installation instructions in NECA NEIS 130.

2. Mounting Heights: Unless otherwise indicated in Contract Documents, comply with mounting heights recommended in NECA NEIS 1.
3. Receptacle Orientation: Unless otherwise indicated in Contract Documents, orient receptacle to match configuration diagram in NEMA WD 6.

    a. Hospital-Grade Receptacle Orientation: Orient receptacle with ground pin or neutral pin at top.

4. Consult Architect for resolution of conflicting requirements.

C. Identification:

1. Identify cover or cover plate for device with panelboard identification and circuit number in accordance with Section 260553 "Identification for Electrical Systems."

    a. Mark cover or cover plate using hot, stamped, or engraved machine printing with black-filled lettering, and provide durable wire markers or tags inside device box or outlet box.
    b. Healthcare Facilities: Distinctively identify covers or cover plates of device boxes and outlet boxes that are supplied from life safety and critical branch power supplies following facility's standard practice.

D. Interfaces with Other Work:

1. Do not install Type 3 SPD, including surge-protected relocatable taps and power strips, on branch circuit downstream of GFCI device.

1.16 INSTALLATION OF LOCKING RECEPTACLES

A. Comply with manufacturer's instructions.

B. Reference Standards:

1. Unless more stringent requirements are specified in Contract Documents or manufacturers' instructions, comply with installation instructions in NECA NEIS 130.
2. Mounting Heights: Unless otherwise indicated in Contract Documents, comply with mounting heights recommended in NECA NEIS 1.
3. Receptacle Orientation: Unless otherwise indicated in Contract Documents, orient receptacle to match configuration diagram in NEMA WD 6.
4. Consult Architect for resolution of conflicting requirements.

C. Identification:

1. Identify cover or cover plate for device with panelboard identification and circuit number in accordance with Section 260553 "Identification for Electrical Systems."

    a. Mark cover or cover plate using hot, stamped, or engraved machine printing with black-filled lettering, and provide durable wire markers or tags inside device box or outlet box.

b. Healthcare Facilities: Distinctively identify covers or cover plates of device boxes and outlet boxes that are supplied from life safety and critical branch power supplies following facility's standard practice.

1.17 INSTALLATION OF PIN-AND-SLEEVE RECEPTACLES

A. Comply with manufacturer's instructions.

B. Reference Standards:

1. Unless more stringent requirements are specified in Contract Documents or manufacturers' instructions, comply with installation instructions in NECA NEIS 130.
2. Mounting Heights: Unless otherwise indicated in Contract Documents, comply with mounting heights recommended in NECA NEIS 1.
3. Receptacle Orientation: Unless otherwise indicated in Contract Documents, orient receptacle to match configuration diagram in UL 1686.
4. Consult Architect for resolution of conflicting requirements.

C. Identification:

1. Identify cover or cover plate for device with panelboard identification and circuit number in accordance with Section 260553 "Identification for Electrical Systems."

a. Mark cover or cover plate using hot, stamped, or engraved machine printing with black-filled lettering, and provide durable wire markers or tags inside device box or outlet box.
b. Healthcare Facilities: Distinctively identify covers or cover plates of device boxes and outlet boxes that are supplied from life safety and critical branch power supplies following facility's standard practice.

1.18 INSTALLATION OF CORD REELS AND FITTINGS

A. Comply with manufacturer's instructions.

1.19 INSTALLATION OF CONNECTORS, CORDS, AND PLUGS

A. Comply with manufacturer's instructions.

1.20 FIELD QUALITY CONTROL OF SWITCHES

A. Field tests and inspections must be witnessed by Architect.

B. Tests and Inspections:

1. Perform tests and inspections in accordance with manufacturers' instructions.

C. Nonconforming Work:

1. Unit will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

D. Assemble and submit test and inspection reports.

E. Manufacturer Services:

1. Engage factory-authorized service representative to support field tests and inspections.

1.21 FIELD QUALITY CONTROL OF STRAIGHT-BLADE RECEPTACLES

A. Field tests and inspections must be witnessed by Architect.

B. Tests and Inspections:

1. Insert and remove test plug to verify that device is securely mounted.
2. Verify polarity of hot and neutral pins.
3. Measure line voltage.
4. Measure percent voltage drop.
5. Measure grounding circuit continuity; impedance must be not greater than 2 ohms.
6. Healthcare Facilities: Test straight-blade receptacles in patient care spaces with receptacle pin tension test instrument in accordance with NFPA 99. Retention force of ground pin must be not less than 115 g (4 oz).
7. Perform additional installation and maintenance inspections and diagnostic tests in accordance with NECA NEIS 130 and manufacturers' instructions.

C. Nonconforming Work:

1. Device will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

D. Assemble and submit test and inspection reports.

E. Manufacturer Services:

1. Engage factory-authorized service representative to support field tests and inspections.

1.22 FIELD QUALITY CONTROL OF LOCKING RECEPTACLES

A. Field tests and inspections must be witnessed by Architect.

B. Tests and Inspections:

1. Insert and remove test plug to verify that device is securely mounted.
2. Verify polarity of hot and neutral pins.
3. Measure line voltage.

4. Measure percent voltage drop.
5. Measure grounding circuit continuity; impedance must be not greater than 2 ohms.
6. Perform additional installation and maintenance inspections and diagnostic tests in accordance with NECA NEIS 130 and manufacturers' instructions.

C. Nonconforming Work:

1. Device will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

D. Assemble and submit test and inspection reports.

E. Manufacturer Services:

1. Engage factory-authorized service representative to support field tests and inspections.

1.23 FIELD QUALITY CONTROL OF PIN-AND-SLEEVE RECEPTACLES

A. Field tests and inspections must be witnessed by Architect.

B. Tests and Inspections:

1. Insert and remove test plug to verify that device is securely mounted.
2. Measure line voltage.
3. Measure percent voltage drop.
4. Measure ground impedance, which must be not greater than 2 ohms.
5. Perform additional installation and maintenance inspections and diagnostic tests in accordance with NECA NEIS 130 and manufacturers' instructions.

C. Nonconforming Work:

1. Device will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

D. Assemble and submit test and inspection reports.

E. Manufacturer Services:

1. Engage factory-authorized service representative to support field tests and inspections.

1.24 FIELD QUALITY CONTROL OF CORD REELS AND FITTINGS

A. Field tests and inspections must be witnessed by Architect.

B. Tests and Inspections:

1. Perform tests and inspections indicated in manufacturer's instructions.

2. See Section 014000 "Quality Requirements" for retesting and reinspecting requirements and Section 017300 "Execution" for requirements for correcting the Work.

C. Nonconforming Work:

1. Components and assemblies will be considered defective if they do not pass tests and inspections.
2. Remove and replace defective units and retest.

D. Assemble and submit test and inspection reports.

E. Manufacturer Services:

1. Engage factory-authorized service representative to support field tests and inspections.

1.25 FIELD QUALITY CONTROL OF CONNECTORS, CORDS, AND PLUGS

A. Field tests and inspections must be witnessed by Architect.

B. Tests and Inspections:

1. Perform tests and inspections indicated in manufacturer's instructions.

C. Nonconforming Work:

1. Unit will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

D. Assemble and submit test and inspection reports.

E. Manufacturer Services:

1. Engage factory-authorized service representative to support field tests and inspections.

1.26 SYSTEM STARTUP FOR SWITCHES

A. Perform startup service.

1. Complete installation and startup checks for momentary switchesand dimmer switches in accordance with manufacturer's instructions.

1.27 ADJUSTING

A. Occupancy Adjustments for Controlled Receptacles: When requested within 12 months from 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.

B. Cord Reels and Fittings: Adjust spring mechanisms and moving parts of cord reels and fittings to function smoothly, and lubricate as recommended in writing by manufacturer.

1.28 PROTECTION

A. Devices:

1. Schedule and sequence installation to minimize risk of contamination of wires and cables, devices, device boxes, outlet boxes, covers, and cover plates by plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other materials.
2. After installation, protect wires and cables, devices, device boxes, outlet boxes, covers, and cover plates from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

B. Cord Reels and Fittings:

1. After installation, protect cord reels and fittings from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

C. Connectors, Cords, and Plugs:

1. After installation, protect connectors, cords, and plugs from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 262726

SECTION 262813 - FUSES

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. Enclosed controllers.
c. Enclosed switches.

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 and in PDF format.
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 017700 "Closeout Procedures," Section 017823 "Operation and Maintenance Data," 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 and in PDF format.
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 (5 deg C) or more than 100 deg F (38 deg C), apply manufacturer's ambient temperature adjustment factors to fuse ratings.

1.7 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by the following provide products by one of the following available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Bussmann
2. Littlefuse

B. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

1.8 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, current-limiting, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

1. Type RK-1: zero- to 600-A rating, 200 kAIC, time delay.
2. Type RK-5: zero- to 600-A rating, 200 kAIC, time delay.
3. Type J: 600-V, zero- to 600-A rating, 200 kAIC, time delay.
4. Type L: 600-V, 601- to 6000-A rating, 200 kAIC, time delay.

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.

1.9 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.

1.10 FUSE APPLICATIONS

A. Cartridge Fuses:

1. Motor Branch Circuits: Class RK1, time delay.
2. Large Motor Branch (601-4000 A): Class L, time delay.
3. Power Electronics Circuits: Class J, high speed.
4. Other Branch Circuits: Class RK1, time delay.
5. Control Transformer Circuits: Class CC, time delay, control transformer duty.
6. Provide open-fuse indicator fuses or fuse covers with open fuse indication.

1.11 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

1.12 IDENTIFICATION

A. Install labels complying with requirements for identification specified in Section 260553 "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 262813

SECTION 262816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

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 electronic 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 017823 "Operation and Maintenance Data," 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 and electronic 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 Altitude: Not exceeding 7400 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(s) from date of Substantial Completion.

1.11 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."

1.12 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.

1.13 FUSIBLE SWITCHES

A. Type HD, Heavy Duty:

1. UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate indicated fuses.
2. Lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

B. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Where 4W system is needed. Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
4. Auxiliary Contact Kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating -240-V ac.
5. Hookstick Handle: Allows use of a hookstick to operate the handle.
6. Lugs: Mechanical type, suitable for number, size, and conductor material.
7. Service-Rated Switches: Labeled for use as service equipment.

1.14 NONFUSIBLE SWITCHES

A. 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.

B. 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. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
4. Auxiliary Contact Kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating - 240-V ac.
5. Hookstick Handle: Allows use of a hookstick to operate the handle.
6. Lugs: Mechanical type, suitable for number, size, and conductor material.
7. Service-Rated Switches: Labeled for use as service equipment.

1.15 SHUNT TRIP SWITCHES

A. General Requirements: Comply with ASME A17.1, UL 50, and UL 98, with Class J fuse block and 200-kA interrupting and short-circuit current rating.

B. Type HD, Heavy-Duty, Three Pole, Single-Throw Fusible Switch: UL 98 and NEMA KS 1; integral shunt trip mechanism; horsepower rated, with clips or bolt pads to accommodate fuses; lockable handle with capability to accept three padlocks; interlocked with cover in closed position.

C. Control Circuit: 120-V ac; obtained from integral control power transformer, with primary and secondary fuses, with a control power transformer of enough capacity to operate shunt trip, pilot, indicating and control devices.

D. Accessories:

1. Mechanically interlocked auxiliary contacts that change state when switch is opened and closed.
2. Form C alarm contacts that change state when switch is tripped.
3. Three-pole, double-throw, fire-alarm voltage monitoring relay complying with NFPA 72.
4. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
5. Isolated Ground Kit: Internally mounted; insulated, labeled for copper and aluminum neutral conductors.
6. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
7. Auxiliary Contact Kit: Two] NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating - 120-V ac.
8. Hookstick Handle: Allows use of a hookstick to operate the handle.
9. Lugs: Mechanical type, suitable for number, size, and conductor material.
10. Service-Rated Switches: Labeled for use as service equipment.

1.16 MOLDED-CASE CIRCUIT BREAKERS

A. 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.

B. 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.

C. 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 100 percent rated.

D. MCCBs shall be equipped with a device for locking in the isolated position.

E. Lugs shall be suitable for 167 deg F rated wire Standard: Comply with UL 489 with interrupting capacity to comply with available fault currents.

F. 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.

G. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.

H. 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.

I. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller, and let-through ratings less than NEMA FU 1, RK-5.

J. 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.

K. Ground-Fault Circuit-Interrupter (GFCI) Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).

L. Ground-Fault Equipment-Protection (GFEP) Circuit Breakers: With Class B ground-fault protection (30-mA trip).

M. Features and Accessories:

1. Standard frame sizes, trip ratings, and number of poles.
2. Lugs: Mechanical 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. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
6. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
7. 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.
8. Alarm Switch: One NO contact that operates only when circuit breaker has tripped.
9. Electrical Operator: Provide remote control for on, off, and reset operations.

1.17 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 type as indicated.

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 end walls.

D. Operating Mechanism: The circuit-breaker operating handle shall be externally operable with the operating mechanism being an integral part of the box, not the cover. 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.

1.18 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.

1.19 ENCLOSURE ENVIRONMENTAL RATING APPLICATIONS

A. Enclosed Switches and Circuit Breakers: Provide enclosures at installed locations with the following environmental ratings.

1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
2. Outdoor Locations: NEMA 250, Type 3R.
3. Kitchen and Wash-Down Areas: NEMA 250, stainless steel.
4. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4.
5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.

1.20 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.

1.21 IDENTIFICATION

A. Comply with requirements in Section 260553 "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.

1.22 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. 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.

1.23 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 260573 "Overcurrent Protective Device Coordination Study."

END OF SECTION 262816

SECTION 26 2913.03 - MANUAL AND MAGNETIC MOTOR CONTROLLERS

1.1 SUMMARY

A. Section Includes:

1. Manual motor controllers.
2. Enclosed full-voltage magnetic motor controllers.
3. Enclosed reduced-voltage magnetic motor controllers.
4. Multispeed magnetic motor controllers.
5. Enclosures.
6. Accessories.
7. Identification.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For each type of magnetic controller.

1. Include plans, elevations, sections, and mounting details.
2. Indicate dimensions, weights, required clearances, and location and size of each field connection.
3. Wire Termination Diagrams and Schedules: Include diagrams for signal, and control wiring. Identify terminals and wiring designations and color-codes to facilitate installation, operation, and maintenance. Indicate recommended types, wire sizes, and circuiting arrangements for field-installed wiring, and show circuit protection features. Differentiate between manufacturer-installed and field-installed wiring.
4. Include features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates, for magnetic controllers, from manufacturer.

B. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.6 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 use.

B. UL Compliance: Fabricate and label magnetic motor controllers to comply with UL 508 and UL 60947-4-1.

C. NEMA Compliance: Fabricate motor controllers to comply with ICS 2.

D. Seismic Performance: Magnetic controllers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the controller will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event"
2. Component Importance Factor: 1.5.

1.7 MANUAL MOTOR CONTROLLERS

A. Motor-Starting Switches (MSS): "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off or on.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB, Motion Business.
b. Eaton.
c. Rockwell Automation, Inc.
d. Siemens Industry, Inc., Energy Management Division.
e. Square D; Schneider Electric USA.

2. Standard: Comply with NEMA ICS 2, general purpose, Class A.
3. Configuration: Nonreversing, Reversing and Two speed.
4. Surface mounting.
5. Green pilot light.
6. Additional Nameplates: FORWARD and REVERSE for reversing switches, HIGH and LOW for two-speed switches.

B. Fractional Horsepower Manual Controllers (FHPMC): "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off, on, or tripped.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB, Electrification Business.

b. ABB, Motion Business.
c. Eaton.
d. Rockwell Automation, Inc.
e. Siemens Industry, Inc., Energy Management Division.
f. Square D; Schneider Electric USA.

2. Configuration: Nonreversing, Two speed.
3. Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, Class 10 tripping characteristics; heaters matched to nameplate full-load current of actual protected motor; external reset push button; bimetallic type.
4. Overload Relays: NEMA ICS 2, bimetallic class as schedule on Drawings.
5. Pilot Light: Red.

1.8 ENCLOSED FULL-VOLTAGE MAGNETIC MOTOR CONTROLLERS

A. Description: Across-the-line start, electrically held, for nominal system voltage of 600-V ac and less.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ABB, Electrification Business.
2. ABB, Motion Business.
3. Eaton.
4. Rockwell Automation, Inc.
5. Siemens Industry, Inc., Energy Management Division.
6. Square D; Schneider Electric USA.

C. Standard: Comply with NEMA ICS 2, general purpose, Class A.

D. Configuration: Nonreversing.

E. Contactor Coils: Pressure-encapsulated type with coil transient suppressors when indicated.

1. Operating Voltage: Manufacturer's standard, unless indicated.

F. Control Power:

1. For on-board control power, obtain from line circuit or from integral CPT. The CPT shall have capacity to operate integral devices and remotely located pilot, indicating, and control devices.

a. Spare CPT Capacity: 100 VA.

G. Overload Relays:

1. Thermal Overload Relays:

a. Inverse-time-current characteristic.

b. Class 10 tripping characteristic.
c. Heaters in each phase shall be matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
d. Ambient compensated.
e. Automatic resetting.

2. Solid-State Overload Relay:
a. Switch or dial selectable for motor-running overload protection.
b. Sensors in each phase.
c. Class 10/20 selectable tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
d. Class II ground-fault protection shall comply with UL 1053 to interrupt low-level ground faults. The ground-fault detection system shall include circuitry that will prevent the motor controller from tripping when the fault current exceeds the interrupting capacity of the controller. Equip with start and run delays to prevent nuisance trip on starting, and a trip indicator.

H. Digital communication module, using RS-485 Modbus , 4-wire connection to host devices with a compatible port to transmit the following to the LAN:

1. Instantaneous rms current each phase, and 3-phase average.
2. Voltage: L-L for each phase, L-L 3-phase average, L-N each phase and L-N 3-phase average - rms.
3. Active Energy (kWh): 3-phase total.
4. Power Factor: 3-phase total.

1.9 ENCLOSED REDUCED-VOLTAGE MAGNETIC MOTOR CONTROLLERS

A. Description: Electrically held; closed-transition; adjustable time delay on transition, 600-V ac or less.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ABB, Electrification Business.
2. ABB, Motion Business.
3. Eaton.
4. Rockwell Automation, Inc.
5. Siemens Industry, Inc., Energy Management Division.
6. Square D; Schneider Electric USA.

C. Standard: Comply with NEMA ICS 2, general purpose, Class A.

D. Configuration:

1. Wye-Delta Controller: Four contactors, with a three-phase starting resistor/reactor bank.
2. Part-Winding Controller: Separate START and RUN contactors, field-selectable for 1/2- or 2/3-winding start mode, with either six- or nine-lead motors; with separate overload relays for starting and running sequences.

3. Autotransformer Reduced-Voltage Controller: Medium-duty service, with integral overtemperature protection; taps for starting at 50, 65, and 80 percent of line voltage; two START and one RUN contactors.

E. Contactor Coils: Pressure-encapsulated type with coil transient suppressors when indicated.

1. Operating Voltage: Manufacturer's standard, unless indicated.

F. Control Power: 24-V ac; obtained from integral CPT, with primary and secondary fuses, with CPT of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.

1. Spare CPT Capacity: 100 VA.

G. Overload Relays:

1. Thermal Overload Relays: Bimetallic type.

a. Inverse-time-current characteristic.
b. Class 10 tripping characteristic.
c. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
d. Ambient compensated.
e. Automatic resetting.

2. Solid-State Overload Relay:

a. Switch or dial selectable for motor-running overload protection.
b. Sensors in each phase.
c. Class 10/20 selectable tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
d. Class II Ground-Fault Protection: Comply with UL 1053 to interrupt low-level ground faults. The ground-fault detection system shall include circuitry that will prevent the motor controller from tripping when the fault current exceeds the interrupting capacity of the controller. Equip with start and run delays to prevent nuisance trip on starting, and a trip indicator.

H. Digital Communication Module: RS-485 Modbus 4-wire connection to host devices with a compatible port to transmit the following to the LAN:

1. Instantaneous rms current each phase, and 3-phase average.
2. Voltage: L-L for each phase, L-L 3-phase average, L-N each phase and L-N 3-phase average - rms.
3. Active Energy (kWh): 3-phase total.
4. Power Factor: 3-phase total.

1.10 MULTISPEED MAGNETIC CONTROLLERS

A. Description: Two speed, full voltage, across the line, electrically held.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ABB, Electrification Business.
2. ABB, Motion Business.
3. Eaton.
4. Rockwell Automation, Inc.
5. Siemens Industry, Inc., Energy Management Division.
6. Square D; Schneider Electric USA.

C. Standard: Comply with NEMA ICS 2, general purpose, Class A.

1. Configuration: Nonreversing, multispeed.
2. Contactor Coils: Pressure-encapsulated type with coil transient suppressors.
    a. Operating Voltage: Manufacturer's standard, unless indicated.
3. Power Contacts: Totally enclosed, double break, silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.
4. Control Power: 24-V ac; obtained from integral CPT, with primary and secondary fuses, with CPT of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.
    a. Spare CPT Capacity: 100 VA.
5. Compelling relays shall ensure that motor will start only at low speed.
6. Accelerating timer relays shall ensure properly timed acceleration through speeds lower than that selected.
7. Decelerating timer relays shall ensure automatically timed deceleration through each speed.
8. Antiplugging timer relays shall ensure a time delay when transferring from FORWARD to REVERSE and back.

D. Overload Relays:

1. Thermal Overload Relays: Bimetallic type.
    a. Inverse-time-current characteristic.
    b. Class 10 tripping characteristic.
    c. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
    d. Ambient compensated.
    e. Automatic resetting.
2. Solid-State Overload Relay:

a. Switch or dial selectable for motor-running overload protection.
b. Sensors in each phase.
c. Class 10/20 selectable tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
d. Class II ground-fault protection shall comply with UL 1053 to interrupt low-level ground faults. The ground-fault detection system shall include circuitry that will prevent the motor controller from tripping when the fault current exceeds the interrupting capacity of the controller. Equip with start and run delays to prevent nuisance trip on starting, and a trip indicator.
e. Digital communication module, using RS-485 Modbus, 4-wire connection to host devices with a compatible port to transmit the following to the LAN:

1) Instantaneous rms current each phase, and 3-phase average.
2) Voltage: L-L for each phase, L-L 3-phase average, L-N each phase and L-N 3-phase average - rms.
3) Active Energy (kWh): 3-phase total.
4) Power Factor: 3-phase total.

1.11 ENCLOSURES

A. Comply with NEMA 250, type designations as indicated on Drawings, complying with environmental conditions at installed location.

B. The construction of the enclosures shall comply with NEMA ICS 6.

1.12 ACCESSORIES

A. General Requirements for Control Circuit and Pilot Devices: NEMA ICS 5; factory installed in controller enclosure cover unless otherwise indicated.

1. Push Buttons, Pilot Lights, and Selector Switches: Standard-duty, except as needed to match enclosure type. Heavy-duty or oil-tight where indicated in the controller schedule.

a. Push Buttons: As indicated in the controller schedule.
b. Pilot Lights: As indicated in the controller schedule.

2. Elapsed Time Meters: Heavy duty with digital readout in hours; resettable.
3. Meters: Panel type, 2-1/2-inch minimum size with 90- or 120-degree scale and plus or minus two percent accuracy. Where indicated, provide selector switches with an off position.

B. Motor protection relays shall be with solid-state sensing circuit and isolated output contacts for hardwired connections.

1. Phase-failure.
2. Phase-reversal, with bicolor LED to indicate normal and fault conditions. Automatic reset when phase reversal is corrected.
3. Under/overvoltage, operate when the circuit voltage reaches a preset value, and drop out when the operating voltage drops to a level below the preset value. Include adjustable time-delay setting.

1.13 IDENTIFICATION

A. Controller Nameplates: Baked enamel signs, as described in Section 260553 "Identification for Electrical Systems," for each compartment, mounted with corrosion-resistant screws.

B. Arc-Flash Warning Labels:

1. Comply with requirements in Section 260573.19 "Arc-Flash Hazard Analysis." Produce a 3.5-by-5-inch self-adhesive equipment label for each work location included in the analysis.
2. Comply with requirements in Section 260553 "Identification for Electrical Systems." Produce a 3.5-by-5-inch self-adhesive equipment label for each work location included in the analysis. Labels shall be machine printed, with no field-applied markings.

a. 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.

b. Labels shall be machine printed, with no field-applied markings.

1.14 INSTALLATION

A. Comply with NECA 1.

B. Wall-Mounted Controllers: Install magnetic controllers on walls with tops at uniform height indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not at walls, provide freestanding racks complying with Section 260529 "Hangers and Supports for Electrical Systems" unless otherwise indicated.

C. Floor-Mounted Controllers: Install controllers on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."

D. Comply with requirements for seismic control devices specified in Section 260548.16 "Seismic Controls for Electrical Systems."

E. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

F. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

G. Setting of Overload Relays: Select and set overloads on the basis of full-load current rating as shown on motor nameplate. Adjust setting value for special motors as required by NFPA 70 for motors that are high-torque, high-efficiency, and so on.

1.15 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

1.16 FIELD QUALITY CONTROL

A. Perform tests and inspections with the assistance of a factory-authorized service representative.

B. Tests and Inspections:

1. Comply with the provisions of NFPA 70B, "Testing and Test Methods" Chapter.
2. Visual and Mechanical Inspection:
    a. Compare equipment nameplate data with drawings and specifications.
    b. Inspect physical and mechanical condition.
    c. Inspect anchorage, alignment, and grounding.
    d. Verify the unit is clean.
    e. Inspect contactors:
        1) Verify mechanical operation.
        2) Verify contact gap, wipe, alignment, and pressure are according to manufacturer's published data.
    f. Motor-Running Protection:
        1) Verify overload element rating is correct for its application.
        2) If motor-running protection is provided by fuses, verify correct fuse rating.
    g. Inspect bolted electrical connections for high resistance using one of the two following methods:
        1) Use a low-resistance ohmmeter. Compare bolted connection resistance values with 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 according to manufacturer's published data or NETA ATS Table 100.12. Bolt-torque levels shall be according to manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.

h. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

3. Electrical Tests:

a. For the contactor and circuit breaker, 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. Insulation-resistance values shall be according to manufacturer's published data or NETA ATS Table 100.1. In the absence of manufacturer's published data, use Table 100.5. Values of insulation resistance less than those of this table or manufacturer's recommendations shall be investigated and corrected.
b. Measure fuse resistance. Investigate fuse-resistance values that deviate from each other by more than 15 percent.
c. Test motor protection devices according to manufacturer's published data.
d. Test circuit breakers as follows:

1) Operate the circuit breaker to ensure smooth operation.
2) For adjustable circuit breakers, adjust protective device settings according to the coordination study. Comply with coordination study recommendations.

e. Perform operational tests by initiating control devices.

C. Motor controller will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

1.17 SYSTEM FUNCTION TESTS

A. System function tests shall prove the correct interaction of sensing, processing, and action devices. Perform system function tests after field quality control tests have been completed and all components have passed specified tests.

1. Develop test parameters and perform tests for the purpose of evaluating performance of integral components and their functioning as a complete unit within design requirements and manufacturer's published data.
2. Verify the correct operation of interlock safety devices for fail-safe functions in addition to design function.
3. Verify the correct operation of sensing devices, alarms, and indicating devices.

B. Motor controller will be considered defective if it does not pass the system function tests and inspections.

C. Prepare test and inspection reports.

1.18 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain switchgear.

END OF SECTION 262913.03

SECTION 264313 - SURGE PROTECTION FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS

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 field-mounted SPDs for low-voltage (120 to 600 V) power distribution and control equipment.

B. Related Requirements:

1. Section 262413 "Switchboards" for factory-installed SPDs.
2. Section 262416 "Panelboards" for factory-installed SPDs.

1.3 DEFINITIONS

A. Inominal: Nominal discharge current.

B. MCOV: Maximum continuous operating voltage.

C. Mode(s), also Modes of Protection: The pair of electrical connections where the VPR applies.

D. MOV: Metal-oxide varistor; an electronic component with a significant non-ohmic current-voltage characteristic.

E. OCPD: Overcurrent protective device.

F. SCCR: Short-circuit current rating.

G. SPD: Surge protective device.

H. VPR: Voltage protection rating.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

2. Copy of UL Category Code VZCA certification, as a minimum, listing the tested values for VPRs, Inominal ratings, MCOVs, type designations, OCPD requirements, model numbers, system voltages, and 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 replace or replace SPDs that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Ten years from date of Substantial Completion.

1.8 GENERAL SPD REQUIREMENTS

A. SPD with 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. Comply with UL 1449.

D. MCOV of the SPD shall be the nominal system voltage.

1.9 SERVICE ENTRANCE SUPPRESSOR

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton.
2. SIEMENS Industry, Inc.; Energy Management Division.
3. Square D; by Schneider Electric.

B. SPDs: Comply with UL 1449, Type 1.

C. SPDs: Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1449, Type 1.

1. SPDs with the following features and accessories:

a. Integral disconnect switch.
b. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
c. Indicator light display for protection status.
d. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status.
e. Surge counter.

D. Comply with UL 1283.

E. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 320 kA. 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 208Y/120 V, three-phase, four-wire circuits shall not exceed the following:

1. Line to Neutral: 1200 V for 480Y/277 V 700 V for 208Y/120 V.
2. Line to Ground: 1200 V for 480Y/277 V 1200 V for 208Y/120 V.
3. Line to Line: 2000 V for 480Y/277 /V 1000 V for 208Y/120 V.

G. SCCR: Equal or exceed 100 kA.

1.10 PANEL SUPPRESSORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton.
2. SIEMENS Industry, Inc.; Energy Management Division.
3. Square D; by Schneider Electric.

B. SPDs: Comply with UL 1449, Type 1.

1. Include LED indicator lights for power and protection status.
2. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
3. Include Form-C contacts rated at 5 A 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.

C. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 100 kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.

D. Comply with UL 1283.

E. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V and 208Y/120 V, three-phase, four-wire circuits shall not exceed the following:

1. Line to Neutral: 1200 V for 480Y/277 V 700 V for 208Y/120 V.
2. Line to Ground: 1200 V for 480Y/277 V 700 V for 208Y/120 V.
3. Neutral to Ground: 1200 V for 480Y/277 V 700 V for 208Y/120 V.
4. Line to Line: 2000 V for 480Y/277 V 1200 V for 208Y/120 V.

F. 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: 700 V.
3. Neutral to Ground: 700 V.
4. Line to Line: 1200 V.

G. SCCR: Equal or exceed 100 kA.

1.11 ENCLOSURES

A. Indoor Enclosures: NEMA 250, Type 1.

B. Outdoor Enclosures: NEMA 250, Type 3R

1.12 CONDUCTORS AND CABLES

A. Power Wiring: Same size as SPD leads, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

1.13 INSTALLATION

A. Comply with NECA 1.

B. Install an OCPD or disconnect as required to comply with the UL listing of the SPD.

C. Install SPDs with conductors between suppressor and points of attachment as short and straight as possible, and adjust circuit-breaker positions to achieve shortest and straightest leads. Do not splice and extend SPD leads unless specifically permitted by manufacturer. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.

D. Use crimped connectors and splices only. Wire nuts are unacceptable.

E. Wiring:

1. Power Wiring: Comply with wiring methods in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
2. Controls: Comply with wiring methods in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

1.14 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 Specifications.
2. Inspect anchorage, alignment, grounding, and clearances.
3. Verify that electrical wiring installation complies with manufacturer's written installation requirements.

B. An SPD will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

1.15 STARTUP SERVICE

A. Complete startup checks according to 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, and reconnect them immediately after the testing is over.

C. Energize SPDs after power system has been energized, stabilized, and tested.

1.16 DEMONSTRATION

A. Train Owner's maintenance personnel to operate and maintain SPDs.

END OF SECTION 264313

SECTION 265119 - LED INTERIOR LIGHTING

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 the following types of LED luminaires:

1. Cylinder.
2. Downlight.
3. Highbay, linear.
4. Linear industrial.
5. Lowbay.
6. Parking garage.
7. Recessed linear.
8. Strip light.
9. Surface mount, linear.
10. Surface mount, nonlinear.
11. Suspended, linear.
12. Suspended, nonlinear.
13. Materials.
14. Finishes.
15. Luminaire support.

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.
2. Section 260943.23 "Relay-Based Lighting Controls" for manual or programmable control systems with low-voltage control wiring or data communication circuits.

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 IES Lighting Measurements Testing and Calculation Guides, of each luminaire type.

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.

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. Samples: For each luminaire and for each color and texture with standard factory-applied finish.

D. Samples for Initial Selection: For each type of luminaire with custom factory-applied finishes.

1. Include Samples of luminaires and accessories involving color and finish selection.

E. Samples for Verification: For each type of luminaire.

1. Include Samples of luminaires and accessories to verify finish selection.

F. Product Schedule: For luminaires and lamps. 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 and or luminaires will be attached.
5. Initial access modules for acoustical tile, including size and locations.
6. Items penetrating finished ceiling, including the following:
    a. Other luminaires.
    b. Air outlets and inlets.
    c. Speakers.
    d. Sprinklers.
    e. Access panels.
    f. Ceiling-mounted projectors.
7. Moldings.

B. Qualification Data: For testing laboratory providing photometric data for luminaires.

C. Seismic Qualification Certificates: 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.

D. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Product Certificates: For each type of luminaire.

F. Product Test Reports: For each luminaire, for tests performed by manufacturer and witnessed by a qualified testing agency.

G. 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 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: Ten for every 100 of each type and rating installed. Furnish at least one of each type.
2. Diffusers and Lenses: One for every 100 of each type and rating installed. Furnish at least one of each type.
3. Globes and Guards: One for every 20 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 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.

E. Mockups: For interior luminaires in room or module mockups, 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. 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.

B. Warranty Period: Five year(s) from date of Substantial Completion.

1.11 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE 7.

B. Seismic Performance: Luminaires and lamps 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."

1.12 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. Standards:

1. ENERGY STAR certified.
2. California Title 24 compliant.
3. NRTL Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by an NRTL.
4. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.
5. UL Listing: Listed for damp location.
6. Recessed luminaires shall comply with NEMA LE 4.

C. Rated lamp life of 50,000 hours to L70.

D. Lamps dimmable from 100 percent to 0 percent of maximum light output.

E. Internal driver.

1.13 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 relamping without use of tools. 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. Acrylic Diffusers: One hundred 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 minimum unless otherwise indicated.

D. Housings:

1. Extruded-aluminum housing and heat sink.
2. Powder-coat finish.

E. 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.

1.14 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.

1.15 LUMINAIRE SUPPORT

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.

1.16 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 luminaire installation. Proceed with installation only after unsatisfactory conditions have been corrected.

1.17 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.

1.18 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 relamping.
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 to structural members in walls.
2. Do not attach luminaires directly to gypsum board.

G. 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.

H. Ceiling-Grid-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.

I. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

1.19 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

1.20 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.

1.21 STARTUP SERVICE

A. Comply with requirements for startup specified in Section 260943.16 "Addressable-Luminaire Lighting Controls."

B. Comply with requirements for startup specified in Section 260943.23 "Relay-Based Lighting Controls."

1.22 ADJUSTING

A. 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 lamps 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 265119

SECTION 265219 - EMERGENCY AND EXIT LIGHTING

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.
2. For exit signs.

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.

7. Moldings.

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 manufacturer and witnessed 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. Lamps: 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.
4. Globes and Guards: One for every 20 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.
2. Warranty Period for Self-Powered Exit Sign Batteries: Two years from date of Substantial Completion. Full warranty shall apply for first year and prorated warranty for the remaining six years.

1.11 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

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."

1.12 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. Lamps for Operation: LEDs; 50,000 hours minimum rated lamp life.

E. Comply with NEMA LE 4 for recessed luminaires.

F. Internal Type Emergency Power Unit: Self-contained, modular, battery-inverter unit, factory mounted within luminaire body.

1. 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.
2. Nightlight Connection: Operate lamp continuously at 40 percent of rated light output.
3. 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.
4. Battery: Sealed, maintenance-free, nickel-cadmium type.
5. Charger: Fully automatic, solid-state, constant-current type with sealed power transfer relay.
6. 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.
7. 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.

1.13 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. Lamps for AC Operation: LEDs; 50,000 hours minimum rated lamp life.
2. Self-Powered Exit Signs (Battery Type): Internal emergency power unit.

1.14 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. Acrylic: 100 percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
2. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.

D. Housings:

1. Extruded aluminum housing and heat sink.

E. Conduit: Electrical metallic tubing, minimum 3/4 inch diameter.

1.15 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.

1.16 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.

1.17 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.

1.18 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 structural members in walls.
2. Do not attach luminaires directly to gypsum board.

F. Suspended Luminaire Support:

1. Pendants and Rods: Where longer than 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. 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.

1.19 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

1.20 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.

1.21 STARTUP SERVICE

A. Perform startup service:

1. Charge emergency power units and batteries minimum of one hour and depress switch to conduct short-duration test.
2. Charge emergency power units and batteries minimum of 24 hours and conduct one-hour discharge test.

1.22 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 265219

SECTION 265613 - LIGHTING POLES AND STANDARDS

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. Poles and accessories for support of luminaires.
2. Luminaire-lowering devices.

1.3 DEFINITIONS

A. EPA: Equivalent projected area.

B. Luminaire: Complete luminaire.

C. Pole: Luminaire-supporting structure, including tower used for large-area illumination.

D. Standard: See "Pole."

1.4 ACTION SUBMITTALS

A. Product Data: For each pole, accessory, and luminaire-supporting and -lowering device, arranged as indicated.

1. Include data on construction details, profiles, EPA, cable entrances, materials, dimensions, weight, rated design load, and ultimate strength of individual components.
2. Include finishes for lighting poles and luminaire-supporting devices.
3. Anchor bolts.
4. Manufactured pole foundations.

B. Shop Drawings:

1. Include plans, elevations, sections, mounting and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, and required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of poles and pole accessories.
4. Foundation construction details, including material descriptions, dimensions, anchor bolts, support devices, and calculations, signed and sealed by a professional engineer licensed in the state of installation.
5. Anchor bolt templates keyed to specific poles and certified by manufacturer.

6. Method and procedure of pole installation. Include manufacturer's written installations.

C. Samples: For each exposed lighting pole, standard, and luminaire-supporting device and for each color and texture specified.

1.5 INFORMATIONAL SUBMITTALS

A. Pole and Support Component Certificates: Signed by manufacturers of poles, certifying that products are designed for indicated load requirements according to AASHTO LTS-6-M and that load imposed by luminaire and attachments has been included in design. The certification shall be based on design calculations signed and sealed by a professional engineer.

B. Qualification Data: For Installer.

C. Seismic Qualification Data: For 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. Material Test Reports:

1. For each foundation component, by a qualified testing agency.
2. For each pole, by a qualified testing agency.

E. Source quality-control reports.

F. Field quality-control reports.

G. Sample Warranty: Manufacturer's standard warranty.

H. Soil test reports

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For poles to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include pole inspection and repair procedures.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Pole repair materials.

1.8 QUALITY ASSURANCE

A. Testing Agency Qualifications: Qualified according to ASTM C 1093 for foundation testing.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Package aluminum poles for shipping according to ASTM B 660.

B. Store poles on decay-resistant skids at least 12 inches above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.

C. Handle wood poles so they will not be damaged. Do not use pointed tools that can indent pole surface more than 1/4 inch deep. Do not apply tools to section of pole to be installed below finished grade.

D. Retain factory-applied pole wrappings on fiberglass and laminated wood poles until right before pole installation. Handle poles with web fabric straps.

E. Retain factory-applied pole wrappings on metal poles until right before pole installation. Handle poles with web fabric straps.

1.10 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of pole(s) that fail in materials or workmanship; that corrode; or that fade, stain, perforate, erode, or chalk due to effects of weather or solar radiation within a specified warranty period. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, or unauthorized repairs from special warranty period.

1. Warranty Period: Five years from date of Substantial Completion.
2. Warranty Period for Corrosion Resistance: Five years from date of Substantial Completion.
3. Warranty Period for Color Retention: Five years from date of Substantial Completion.

1.11 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design pole foundation and pole power system.

B. Seismic Performance: Foundation and pole shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the system will remain in place without separation of any parts when subjected to the seismic forces specified and the system will be fully operational after the seismic event."
2. Component Importance Factor: 1.5.

C. Structural Characteristics: Comply with AASHTO LTS-6-M.

D. Dead Load: Weight of luminaire and its horizontal and vertical supports, lowering devices, and supporting structure, applied according to AASHTO LTS-6-M.

E. Live Load: Single load of 500 lbf distributed according to AASHTO LTS-6-M.

F. Ice Load: Load of 3 lbf/sq. ft., applied according to AASHTO LTS-6-M for applicable areas on the Ice Load Map.

G. Wind Load: Pressure of wind on pole and luminaire, calculated and applied according to AASHTO LTS-6-M.

1. Basic wind speed for calculating wind load for poles 50 feet high or less is 100 mph.

a. Wind Importance Factor: 1.0.
b. Minimum Design Life: 25 years.
c. Velocity Conversion Factor: 1.0.

H. Strength Analysis: For each pole, multiply the actual EPA of luminaires and brackets by a factor of 1.1 to obtain the EPA to be used in pole selection strength analysis.

I. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners and mounting bolts unless otherwise indicated.

1.12 STEEL POLES

A. Source Limitations: Obtain poles from single manufacturer or producer.

B. Source Limitations: For poles, obtain each color, grade, finish, type, and variety of pole from single source with resources to provide products of consistent quality in appearance and physical properties.

C. Poles: Comply with ASTM A 500/A 500M, Grade B carbon steel with a minimum yield of 46,000 psig; one-piece construction up to 40 feet in height with access handhole in pole wall.

1. Shape: Square, straight.
2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.

D. Steel Mast Arms: Single-arm type, continuously welded to pole attachment plate. Material and finish same as plate.

E. Brackets for Luminaires: Detachable, cantilever, without underbrace.

1. Adaptor fitting welded to pole, allowing the bracket to be bolted to the pole-mounted adapter, then bolted together with galvanized-steel bolts.

2. Cross Section: Tapered oval, with straight tubular end section to accommodate luminaire. Match pole material and finish.

F. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.

G. Fasteners: Stainless steel, size and type as determined by manufacturer. Corrosion-resistant items compatible with support components.

1. Materials: Compatible with poles and standards as well as the substrates to which poles and standards are fastened and shall not cause galvanic action at contact points.
2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication unless otherwise indicated.

H. Grounding and Bonding Lugs: Welded 1/2-inch threaded lug, complying with requirements in Section 260526 "Grounding and Bonding for Electrical Systems," listed for attaching grounding and bonding conductors of type and size indicated, and accessible through handhole.

I. Steps: Fixed steel, with nonslip treads.

1. For climbing positions, install at 15-inch vertical spacing, alternating on opposite sides of pole, oriented 180 degrees from each other; first step shall be at an elevation 10 feet above finished grade.
2. For working positions, install steps on opposite side of pole, oriented 180 degrees from each other at the same elevation.

J. Handhole: Oval shaped, with minimum clear opening of 2-1/2 by 5 inches, with cover secured by stainless-steel captive screws.

K. Cable Support Grip: Wire-mesh type with rotating attachment eye, sized for diameter of cable and rated for a minimum load equal to weight of supported load multiplied by a 5.0 safety factor.

L. Prime-Coat Finish: Manufacturer's standard prime-coat finish ready for field painting.

M. Galvanized Finish: After fabrication, hot-dip galvanize according to ASTM A 123/A 123M.

N. Powder-Coat Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" recommendations for applying and designating finishes.

1. Surface Preparation: Clean surfaces according to SSPC-SP 1 to remove dirt, oil, grease, and other contaminants that could impair powder coat bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, according to SSPC-SP 5/NACE No. 1 or SSPC-SP 8.
2. Powder Coat: Comply with AAMA 2604.

a. Electrostatic-applied powder coating; single application and cured to a minimum 2.5- to 3.5-mils dry film thickness. Coat interior and exterior of pole for equal corrosion protection.
b. Color: As selected by Architect from manufacturer's full range.

1.13 POLE ACCESSORIES

A. Base Covers: Manufacturers' standard metal units, finished same as pole, and arranged to cover pole's mounting bolts and nuts.

1.14 MOUNTING HARDWARE

A. Anchor Bolts: Manufactured to ASTM F 1554, Grade 55, with a minimum yield strength of 55,000 psi.

1. Galvanizing: Hot dip galvanized according to ASTM A 153, Class C.
2. Bent rods.
3. Threading: Uniform National Course, Class 2A.

B. Nuts: ASTM A 563, Grade A, Heavy-Hex

1. Galvanizing: Hot dip galvanized according to ASTM A 153, Class C
2. Two nuts provided per anchor bolt shipped with nuts pre-assembled to the anchor bolts.

C. Washers: ASTM F 436, Type 1.

1. Galvanizing: Hot dip galvanized according to ASTM A 153, Class C.
2. Two washers provided per anchor bolt.

1.15 GENERAL FINISH REQUIREMENTS

A. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

B. Appearance of Finished Work: Noticeable variations in same piece are unacceptable. 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.

1.16 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 poles, luminaire-mounting devices, lowering devices, and pole accessories before installation. Components that are scratched, dented, marred, wet, moisture damaged, or visibly damaged are considered defective.

C. Examine roughing-in for foundation and conduit to verify actual locations of installation.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

1.17 POLE FOUNDATION

A. Concrete Pole Foundations: Cast in place, with anchor bolts to match pole-base flange. Structural steel complying with ASTM A 36/A 36M and hot-dip galvanized according to ASTM A 123/A 123 M; and with top-plate and mounting bolts to match pole-base flange and strength required to support pole, luminaire, and accessories. Concrete, reinforcement, and formwork are specified in Section 033000 "Cast-in-Place Concrete."

B. Anchor Bolts: Install plumb using manufacturer-supplied template, uniformly spaced.

1.18 POLE INSTALLATION

A. Alignment: Align pole foundations and poles for optimum directional alignment of luminaires and their mounting provisions on pole.

B. Clearances: Maintain the following minimum horizontal distances of poles from surface and underground features unless otherwise indicated on drawing.

1. Fire Hydrants and Water Piping: 60 inches.
2. Water, Gas, Electric, Communications, and Sewer Lines: 10 feet.
3. Trees: 15 feet from tree trunk.

C. Concrete Pole Foundations: Set anchor bolts according to anchor-bolt templates furnished by pole manufacturer. Concrete materials, installation, and finishing requirements are specified in Section 033000 "Cast-in-Place Concrete."

D. Poles and Pole Foundations Set in Concrete-Paved Areas: Install poles with a minimum 6-inch-wide, unpaved gap between the pole or pole foundation and the edge of the adjacent concrete slab. Fill unpaved ring with pea gravel. Insert material to a level 1 inch below top of concrete slab.

E. Raise and set pole using web fabric slings (not chain or cable) at locations indicated by manufacturer.

1.19 CORROSION PREVENTION

A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum using insulating fittings or treatment.

B. Steel Conduits: Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch-thick, pipe-wrapping plastic tape applied with a 50-percent overlap.

1.20 GROUNDING

A. Ground Metal Poles and Support Structures: Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

1. Install grounding electrode for each pole unless otherwise indicated.
2. Install grounding conductor pigtail in the base for connecting luminaire to grounding system.

B. Ground Nonmetallic Poles and Support Structures: Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

1. Install grounding electrode for each pole.
2. Install grounding conductor and conductor protector.
3. Ground metallic components of pole accessories and foundation.

1.21 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

1.22 FIELD QUALITY CONTROL

A. Special Inspections: Perform the following special inspections:

1. Inspect poles for nicks, mars, dents, scratches, and other damage.
2. System function tests.

END OF SECTION 265613

SECTION 265619 - LED EXTERIOR LIGHTING

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:

1. Section 260923 "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.
2. Section 260943.23 "Relay-Based Lighting Controls" for manual or programmable control systems with low-voltage control wiring or data communication circuits.
3. Section 265613 "Lighting Poles and Standards" for poles and standards used to support exterior lighting equipment.

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. 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 luminaire.

1. Arrange in order of luminaire designation.
2. Include data on features, accessories, and finishes.
3. Include physical description and dimensions of luminaire.

4. Lamps, 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 lamps and accessories identical to those indicated for the luminaire as applied in this Project.
    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.
7. Photoelectric relays.
8. Means of attaching luminaires to supports and indication that the attachment is suitable for components involved.

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.

D. 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. Above-grade utilities and structures.
5. Existing above-grade utilities and structures.
6. Building features.
7. 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 lamp types used on Project. Use ANSI and manufacturers' codes.
2. Provide a list of all photoelectric relay types used on Project; use 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. 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.
2. Diffusers and Lenses: One for every 100 of each type and rating installed. Furnish at least one of each type.
3. Globes and Guards: One for every 20 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. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

E. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

F. 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. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering prior to shipping.

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. 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.

2. Warranty Period: 2 year(s) from date of Substantial Completion.

1.12 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

B. Seismic Performance: Luminaires and lamps 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."

1.13 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.

E. Lamp base complying with ANSI C81.61.

F. Bulb shape complying with ANSI C79.1.

G. CRI of minimum 80. CCT of 3000 K.

H. L70 lamp life of 50,000 hours.

I. Lamps dimmable from 100 percent to 0 percent of maximum light output.

J. Internal driver.

K. Lamp Rating: Lamp marked for outdoor use.

L. Source Limitations: Obtain luminaires from single source from a single manufacturer.

M. 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.

1.14 MATERIALS

A. Metal Parts: Free of burrs and sharp corners and edges.

B. Sheet Metal Components: Corrosion-resistant aluminum. 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 relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping 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 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.

1.15 FINISHES

A. Variations in Finishes: Noticeable variations in same piece are unacceptable. 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.

B. Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and -tested luminaire before shipping. Where indicated, match finish process and color of pole or support materials.

C. Factory-Applied Finish for Aluminum Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20 requirements; and seal aluminum surfaces with clear, hard-coat wax.
3. Class I, Clear-Anodic Finish: AA-M32C22A41 (Mechanical Finish: Medium satin; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.
4. Class I, Color-Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: Medium satin; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker), complying with AAMA 611.

    a. Color: Selected by Architect.

D. 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.

1.16 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.

1.17 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 canopy ceilings for suitable conditions where luminaires will be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

1.18 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.

1.19 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.

E. Supports:

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.

F. Wall-Mounted Luminaire Support:

1. Attached to structural members in walls.

G. Wiring Method: Install cables in raceways. Conceal raceways and cables.

H. Install luminaires level, plumb, and square with finished grade unless otherwise indicated.

I. Coordinate layout and installation of luminaires with other construction.

J. Adjust luminaires that require field adjustment or aiming.

K. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" and Section 260533 "Raceways and Boxes for Electrical Systems" for wiring connections and wiring methods.

1.20 BOLLARD LUMINAIRE INSTALLATION:

A. Align units for optimum directional alignment of light distribution.

1. Install on concrete base with top above finished grade or surface at luminaire location. Cast conduit into base, and shape base to match shape of bollard base. Finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Section 033000 "Cast-in-Place Concrete."

1.21 INSTALLATION OF INDIVIDUAL GROUND-MOUNTED LUMINAIRES

A. Aim as indicated on Drawings.

B. Install on concrete base with top above finished grade or surface at luminaire location. Cast conduit into base, and finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Section 033000 "Cast-in-Place Concrete."

1.22 CORROSION PREVENTION

A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.

B. Steel Conduits: Comply with Section 260533 "Raceways and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch-thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

1.23 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

1.24 FIELD QUALITY CONTROL

A. Inspect each installed luminaire for damage. Replace damaged luminaires and components.

B. 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. Verify operation of photoelectric controls.

C. 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.

2. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.

D. Luminaire will be considered defective if it does not pass tests and inspections.

E. 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.

1.25 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain luminaires.

1.26 ADJUSTING

A. 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 lamps 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 265619

SECTION 270526 - GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEM

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 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 and roof rings.
2. BCT, TMGB, TGBs, and routing of their bonding conductors.

B. Qualification Data: For Installer, installation supervisor, and field inspector.

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. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Result of the ground-resistance test, measured at the point of BCT connection.
b. Result of the bonding-resistance test at each TGB and its nearest grounding electrode.

1.7 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.

1.8 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. 6 AWG.

C. Cable Tray Grounding Jumper:

1. Not smaller than No. 6 AWG and not longer than 12 inches. If jumper is a wire, it shall have a crimped grounding lug with two holes and long barrel for two crimps. If jumper is a flexible braid, it shall have a one-hole ferrule. Attach with grounding screw or connector provided by cable tray manufacturer.
2. Not smaller than No. 10 AWG and not longer than 12 inches. 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 B 3.
2. Stranded Conductors: ASTM B 8.
3. Tinned Conductors: ASTM B 33.

4. Bonding Cable: 28 kcmils, 14 strands of No. 17 AWG conductor, and 1/4 inch 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 wide and 1/16 inch thick.

1.9 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 centers for a two-bolt connection to the busbar.

D. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

1.10 GROUNDING BUSBARS

A. TMGB: Predrilled, wall-mounted, rectangular bars of hard-drawn solid copper, 1/4 by 4 inches 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 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 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 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.

1.11 IDENTIFICATION

A. Comply with requirements for identification products in Section 270553 "Identification for Communications Systems."

1.12 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. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

D. Proceed with connection of the BCT only after unsatisfactory conditions have been corrected.

1.13 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.

1.14 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. Underground Grounding Conductors: Install bare tinned-copper conductor, No. 2 AWG minimum.

C. 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.

D. Conductor Support:

1. Secure grounding and bonding conductors at intervals of not less than 36 inches.

E. 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 intervals.
4. Install grounding and bonding conductors in 3/4-inch 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.

1.15 GROUNDING ELECTRODE SYSTEM

A. The BCT between the TMGB and the ac service equipment ground shall not be smaller than No. 3/0 AWG.

1.16 GROUNDING BUSBARS

A. Indicate locations of grounding busbars on Drawings. Install busbars horizontally, on insulated spacers 2 inches minimum from wall, 12 inches above finished floor unless otherwise indicated.

B. 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.

1.17 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. Interconnections: Interconnect all TGBs with the TMGB with the telecommunications backbone conductor. If more than one TMGB is installed, interconnect TMGBs using the grounding equalizer conductor. The telecommunications backbone conductor and grounding equalizer conductor size shall not be less than 2 kcmils/linear foot (1 sq. mm/linear meter) of conductor length, up to a maximum size of No. 3/0 AWG unless otherwise indicated.

F. Telecommunications Enclosures and Equipment Racks: Bond metallic components of enclosures to the telecommunications bonding and grounding system.. Bond the equipment grounding busbar to the TGB No. 2 AWG bonding conductors.

G. 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.

H. 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.

I. 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.

J. 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.

K. Access Floors: Bond all metal parts of access floors to the TGB.

L. Equipment Room Signal Reference Grid: Provide a low-impedance path between telecommunications cabinets, equipment racks, and the reference grid, using No. 6 AWG bonding conductors.

1. Install the conductors in grid pattern on 4-foot centers, allowing bonding of one pedestal from each access floor tile.
2. Bond the TGB of the equipment room to the reference grid at two or more locations.
3. Bond all conduits and piping entering the equipment room to the TGB at the perimeter of the room.

1.18 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

A. Duct-Bank Grounding Conductor: Bury 12 inches 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 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 above to 6 inches 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.

1.19 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!"

1.20 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. Excessive Ground Resistance: If resistance to ground at the BCT exceeds 5 ohms, notify Architect promptly and include recommendations to reduce ground resistance.

D. Grounding system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

END OF SECTION 270526

SECTION 270528 - PATHWAYS FOR COMMUNICATIONS SYSTEM

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. Hooks.
4. Boxes, enclosures, and cabinets.
5. Polymer-concrete handholes and boxes for exterior underground cabling.

1.3 DEFINITIONS

A. GRC: Galvanized rigid conduit.

B. IMC: Intermediate metal conduit.

1.4 ACTION SUBMITTALS

A. Product data for the following:

1. Surface pathways
2. Wireways and fittings.
3. Boxes, enclosures, and cabinets.
4. Underground handholes and boxes.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Pathway 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 pathway groups with common supports.
2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.
3. Underground ducts, piping, and structures in location of underground enclosures and handholes.

B. Qualification Data: For professional engineer.

C. Seismic Qualification Data: Seismic rating for all pathway racks, enclosures, cabinets, equipment 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 certification is based and their installation requirements.
4. Detailed description of conduit support devices and interconnections on which certification is based and their installation requirements.

D. Source quality-control reports.

1.6 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. IMC: Comply with ANSI C80.6 and UL 1242.

E. PVC-Coated Steel Conduit: PVC-coated GRC.

1. Comply with NEMA RN 1.
2. Coating Thickness: 0.040 inch, minimum.

F. EMT: Comply with ANSI C80.3 and UL 797.

G. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.

1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 1203 and NFPA 70.
2. Fittings for EMT:

   a. Material: Steel.
   b. Type: compression.

3. 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.
4. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch, with overlapping sleeves protecting threaded joints.

H. Joint Compound for IMC, GRC: 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.

1.7 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-40-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.

1.8 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 steel.

E. J shape.

1.9 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 11/16” inches square by 2-1/8 inches deep.

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. Metal Floor Boxes:

1. Material: Cast metal.
2. Type: Fully adjustable.
3. Shape: Rectangular.
4. 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.

F. Nonmetallic Floor Boxes: Nonadjustable, round.

1. Nonmetallic 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. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

H. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, cast aluminum with gasketed cover.

I. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.

1. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

J. Cabinets:

1. NEMA 250, Type 1 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.

1.10 POLYMER-CONCRETE HANDHOLES

A. Description: Molded of sand and aggregate; bound together with polymer resin; and reinforced with steel, fiberglass, or a combination of the two.

B. General Requirements for Polymer Concrete Handholes:

1. Boxes and handholes for use in underground systems shall be listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
2. Boxes installed in wet areas shall be listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
3. Comply with TIA-569-D and SCTE 77.

C. Configuration: Designed for flush burial with integral closed bottom unless otherwise indicated.

D. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.

1. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
2. Cover Legend: Molded lettering, "COMMUNICATIONS".

E. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.

F. Handholes 12 Inches Wide by 24 Inches Long and Larger: Have inserts for cable racks and pulling-in irons installed before concrete is poured.

1.11 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.

1.12 PATHWAY APPLICATION

A. Outdoors: Apply pathway products as specified below unless otherwise indicated:

1. Exposed Conduit: GRC.
2. Concealed Conduit, Aboveground: GRC.
3. Underground Conduit: RNC, Type EPC-40-PVC, direct buried concrete encased where under drive areas.
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, Not Subject to Severe Physical Damage: EMT.
3. Exposed and Subject to Severe Physical Damage: GRC. Pathway locations include the following:

    a. Loading dock.
    b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
    c. Mechanical rooms.

4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
5. Damp or Wet Locations: GRC.
6. Pathways for Optical-Fiber or Communications-Cable Risers in Vertical Shafts: Riser-type, communications-cable pathway 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: ***ASI 035>** Refer to drawings for pathway requirements. **<ASI 035***

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 compression, steel fittings. Comply with NEMA FB 2.10.

E. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.

F. Install surface pathways only where indicated on Drawings.

G. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F (49 deg C).

1.13 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.
4. NECA 101
5. NECA 102.
6. NECA 105.
7. NECA 111.

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 270528.29 "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 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. Install no more than the equivalent of two 90-degree bends in any pathway run. Support within 12 inches of changes in direction. Utilize long radius ells for all optical-fiber cables.

J. Conceal rigid conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.

K. Support conduit within 12 inches of enclosures to which attached.

L. Slabs: DO NOT EMBED PATHWAYS IN SLABS ON GRADE OR ELEVATED SLABS.

M. 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.

N. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of pathway and fittings before making up joints. Follow compound manufacturer's written instructions.

O. Coat field-cut threads on PVC-coated pathway with a corrosion-preventing conductive compound prior to assembly.

P. 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.

Q. Install pathways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus one additional quarter-turn.

R. 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.

S. Cut conduit perpendicular to the length. For conduits of 2-inch trade size and larger, use roll cutter or a guide to ensure cut is straight and perpendicular to the length.

T. 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 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.

U. Install pathway-sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed pathways, 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 pathway-sealing fittings according to NFPA 70.

V. 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.

W. Comply with manufacturer's written instructions for solvent welding PVC conduit and fittings.

X. Expansion-Joint Fittings:

1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F (17 deg C), and that has straight-run length that exceeds 25 feet (7.6 m). Install in each run of aboveground RMC and EMT that is located where environmental temperature change may exceed 100 deg F (55 deg C), and that has straight-run length that exceeds 100 feet (30 m).
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 (70 deg C) temperature change.
    b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F (86 deg C) temperature change.
    c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F (70 deg C) temperature change.
    d. Attics: 135 deg F (75 deg C) 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 (0.06 mm per meter of length of straight run per deg C) 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 (0.0115 mm per meter of length of straight run per deg C) 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.

Y. 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 of slack. The lowest point of the cables shall be no less than 6 inches 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 o.c.
5. Provide a hook at each change in direction.

Z. 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 bottom of box unless otherwise indicated.

AA. 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.

BB. Horizontally separate boxes mounted on opposite sides of walls, so they are not in the same vertical channel.

CC. 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.

DD. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

EE. Set metal floor boxes level and flush with finished floor surface.

FF. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

1.14 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 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 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 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 around conduit 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 270553 "Identification for Communications Systems."

1.15 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

A. Install handholes 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 handholes with bottom below 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.

1.16 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."

1.17 FIRESTOPPING

A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

1.18 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 270528.29 - HANGERS AND SUPPORTS FOR COMMUNICATIONS SYSTEMS

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 for communication raceways.
2. Conduit and cable support devices.
3. Support for conductors in vertical conduit.
4. Mounting, anchoring, and attachment components, including powder-actuated fasteners, mechanical expansion anchors, concrete inserts, clamps, through bolts, toggle bolts, and hanger rods.

B. Related Requirements:

1. Section 270548 "Seismic Controls for Communications Systems" 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 communications hangers and support systems.

1. Trapeze hangers. Include product data for components.
2. Steel slotted-channel systems.
3. Aluminum slotted-channel systems.

4. Nonmetallic slotted-channel systems.
5. Equipment supports.
6. 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 communications systems.

1. Include design calculations and details of trapeze 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 Certificates: For hangers and supports for communications equipment and systems, 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. Welding certificates.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M.

1.6 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.

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 system will be fully operational after the seismic event."
2. Component Importance Factor: 1.5.

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.

1.7 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. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
2. Material for Channel, Fittings, and Accessories: Galvanized steel.
3. Channel Width: Selected for applicable load criteria 1-5/8 inches (41.25 mm) 1).
4. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
5. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
6. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
7. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

B. Conduit and Cable Support Devices: Steel clamps, hangers, 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 non-armored communications 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.
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.
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-steel springhead type.
7. Hanger Rods: Threaded steel.

1.8 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 055000 "Metal Fabrications" for steel shapes and plates.

1.9 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/BICSI 568.
3. TIA-569-D.
4. NECA 101
5. NECA 102.
6. NECA 105.
7. NECA 111.

B. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.

C. Comply with requirements for pathways specified in Section 270528 "Pathways for Communications Systems."

D. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMTs, IMCs, and RMCs as required by scheduled in NECA 1, where its Table 1 lists maximum spacings 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 or other 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 two-bolt conduit clamps.

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.

1.10 SUPPORT INSTALLATION

A. Raceway Support Methods: In addition to methods described in NECA 1, EMT may be supported by openings through structure members, according to NFPA 70.

B. 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 (90 kg).

C. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten communications 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: Use approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To Existing Concrete: Use 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.
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.

D. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

1.11 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Section 055000 "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 communications materials and equipment.

C. Field Welding: Comply with AWS D1.1/D1.1M.

1.12 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 099113 "Exterior Painting", Section 099123 "Interior Painting" 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 270528.29

SECTION 270536 - CABLE TRAYS FOR COMMUNICATIONS SYSTEM

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. Wire-mesh cable tray.
2. Cable tray accessories.
3. Warning signs.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of cable tray.

1. Include data indicating dimensions and finishes for each type of cable tray indicated.

B. Shop Drawings: For each type of cable tray.

1. Show fabrication and installation details of cable trays, including plans, elevations, and sections of components and attachments to other construction elements. Designate components and accessories, including clamps, brackets, hanger rods, splice-plate connectors, expansion-joint assemblies, straight lengths, and fittings.
2. Cable tray layout, showing cable tray route to scale, with relationship between the tray and adjacent structural, electrical, and mechanical elements. Include the following:

    a. Vertical and horizontal offsets and transitions.
    b. Clearances for access above and to sides of cable trays.
    c. Vertical elevation of cable trays above the floor or bottom of ceiling structure.
    d. Load calculations to show dead and live loads as not exceeding manufacturer's rating for tray and its support elements.

C. Delegated-Design Submittal: For seismic restraints.

1. Seismic-Restraint Details: Signed and sealed by a qualified professional engineer, licensed in the state where Project is located, who is responsible for their preparation.
2. Design Calculations: Calculate requirements for selecting seismic restraints.
3. Detail fabrication, including anchorages and attachments to structure and to supported cable trays.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and sections, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Scaled cable tray layout and relationships between components and adjacent structural, electrical, and mechanical elements.
2. Vertical and horizontal offsets and transitions.
3. Clearances for access above and to side of cable trays.
4. Vertical elevation of cable trays above the floor or below bottom of ceiling structure.

B. Seismic Qualification Data: Certificates, for cable trays, 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.

1.5 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design cable tray supports and seismic bracing.

B. Seismic Performance: Cable trays and supports shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the cable trays will remain in place without separation of any parts when subjected to the seismic forces specified."
2. Component Importance Factor: 1.5.

C. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes in cable tray installed outdoors.

1. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

1.6 GENERAL REQUIREMENTS FOR CABLE TRAYS

A. Cable Trays and Accessories: Identified as defined in NFPA 70 and marked for intended location, application, and grounding.

1. Source Limitations: Obtain cable trays and components from single manufacturer.

B. Sizes and Configurations: See the Cable Tray Schedule on Drawings for specific requirements for types, materials, sizes, and configurations.

C. Structural Performance: See articles for individual cable tray types for specific values for the following parameters:

1. Uniform Load Distribution: Capable of supporting a uniformly distributed load on the indicated support span when supported as a simple span and tested according to NEMA VE 1.
2. Concentrated Load: A load applied at midpoint of span and centerline of tray.
3. Load and Safety Factors: Applicable to both side rails and rung capacities.

1.7 WIRE-MESH CABLE TRAY

A. Description:

1. Configuration: Galvanized- steel wire mesh, complying with NEMA VE 1.
2. Width: As indicated on Drawings.
3. Minimum Usable Load Depth As indicated on Drawings.
4. Straight Section Lengths: 10 feet (3.0 m), except where shorter lengths are required to facilitate tray assembly.
5. Structural Performance: Capable of supporting a maximum cable load, with a safety factor of 1.5, plus a 200-lb (90-kg) concentrated load, when tested according to NEMA VE 1.
6. Splicing Assemblies: Bolted type using serrated flange locknuts.
7. Splice-Plate Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.

B. Materials and Finishes:

1. Steel:

a. Straight Sections and Fittings: Steel complies with the minimum mechanical properties of ASTM A 1011/A 1011M, SS, Grade 33.
b. Steel Tray Splice Plates: ASTM A 1011/A 1011M, HSLAS, Grade 50, Class 1.
c. Fasteners: Steel complies with the minimum mechanical properties of ASTM A 510/A 510M, Grade 1008.
d. Finish: Hot-dip galvanized after fabrication, complying with ASTM A123/A123 M, Class B2.
   1) Hardware: Galvanized, ASTM B 633.
e. Finish: Hot-dip galvanized after fabrication, complying with ASTM A 653/A 653M, G90 (Z275).
   1) Hardware: Galvanized, ASTM B 633.
f. Finish: Electrogalvanized after fabrication, complying with ASTM B 633.
   1) Hardware: Galvanized, ASTM B 633.
g. Finish: Epoxy-resin paint.

1) Powder-Coat Enamel: Cable tray manufacturer's recommended primer and corrosion-inhibiting treatment, with factory-applied powder-coat paint.
2) Epoxy-Resin Prime Coat: Cold-curing epoxy primer, MPI# 101.
3) Epoxy-Resin Topcoat: Epoxy, cold-cured gloss, MPI# 77.
4) Hardware: Chromium-zinc plated, ASTM F 1136.

h. Finish: Factory-standard primer, ready for field painting, with chromium-zinc-plated hardware according to ASTM F 1136.

i. Finish: Black oxide finish for support accessories and miscellaneous hardware according to ASTM D 769.

1.8 CABLE TRAY ACCESSORIES

A. Fittings: Tees, crosses, risers, elbows, and other fittings as indicated, of same materials and finishes as cable tray.

B. Barrier Strips: Same materials and finishes as for cable tray.

C. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.

1.9 WARNING SIGNS

A. Comply with requirements for identification in Section 270553 "Identification for Communications Systems."

B. Lettering: 1-1/2-inch- high, black letters on yellow background with legend "Warning! Not To Be Used as Walkway, Ladder, or Support for Ladders or Personnel."

1.10 SOURCE QUALITY CONTROL

A. Testing: Test and inspect cable trays according to NEMA FG 1.

1.11 CABLE TRAY INSTALLATION

A. Install cable trays according to NEMA FG 1.

B. Install cable trays as a complete system, including fasteners, hold-down clips, support systems, barrier strips, adjustable horizontal and vertical splice plates, elbows, reducers, tees, crosses, cable dropouts, adapters, covers, and bonding.

C. Install cable trays so that the tray is accessible for cable installation and all splices are accessible for inspection and adjustment.

D. Remove burrs and sharp edges from cable trays.

E. Join aluminum cable tray with splice plates; use four square neck-carriage bolts and locknuts.

F. Fasten cable tray supports to building structure and install seismic restraints.

G. Design fasteners and supports to carry cable tray, the cables, and a concentrated load of 200 lb (90 kg). Comply with requirements in Section 270529 "Hangers and Supports for Communications Systems." Comply with seismic-restraint details according to Section 270548.16 "Seismic Controls for Communications Systems."

H. Place supports so that spans do not exceed maximum spans on schedules and provide clearances shown on Drawings. Install intermediate supports when cable weight exceeds the load-carrying capacity of the tray rungs.

I. Construct supports from channel members, threaded rods, and other appurtenances furnished by cable tray manufacturer. Arrange supports in trapeze or wall-bracket form as required by application.

J. Support bus assembly to prevent twisting from eccentric loading.

K. Install center-hung supports for single-rail trays designed for 60 versus 40 percent eccentric loading condition, with a safety factor of 3.

L. Locate and install supports according to NEMA FG 1. Do not install more than one cable tray splice between supports.

M. Support wire-basket cable trays with trapeze hangers.

N. Support trapeze hangers for wire-basket trays with 1/4-inch- (6-mm-) diameter rods.

O. Make connections to equipment with flanged fittings fastened to cable trays and to equipment. Support cable trays independent of fittings. Do not carry weight of cable trays on equipment enclosure.

P. Install expansion connectors where cable trays cross building expansion joints and in cable tray runs that exceed dimensions recommended in NEMA FG 1. Space connectors and set gaps according to applicable standard.

Q. Make changes in direction and elevation using manufacturer's recommended fittings.

R. Make cable tray connections using manufacturer's recommended fittings.

S. Seal penetrations through fire and smoke barriers. Comply with requirements in Section 078413 "Penetration Firestopping." Provide EZ Path Fire rated pathway for penetrations through walls.

T. Install capped metal sleeves for future cables through firestop-sealed cable tray penetrations of fire and smoke barriers.

U. Install cable trays with enough workspace to permit access for installing cables.

V. Install barriers to separate cables of different systems, such as power, communications, and data processing; or of different insulation levels, such as 600, 5000, and 15 000 V.

W. Install permanent covers, if used, after installing cable. Install cover clamps according to NEMA VE 2.

X. Clamp covers on cable trays installed outdoors with heavy-duty clamps.

Y. Install warning signs in visible locations on or near cable trays after cable tray installation.

1.12 CABLE TRAY GROUNDING

A. Ground cable trays according to NFPA 70 unless additional grounding is specified. Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems."

B. Cable trays shall be bonded together with splice plates listed for grounding purposes or with listed bonding jumpers.

C. Cable trays with single-conductor power conductors shall be bonded together with a grounding conductor run in the tray along with the power conductors and bonded to the tray at 72-inch intervals. The grounding conductor shall be sized according to NFPA 70, Article 250.122, "Size of Equipment Grounding Conductors," and Article 392, "Cable Trays."

D. When using epoxy- or powder-coat painted cable trays as a grounding conductor, completely remove coating at all splice contact points or ground connector attachment. After completing splice-to-grounding bolt attachment, repair the coated surfaces with coating materials recommended by cable tray manufacturer.

E. Bond cable trays to power source for cables contained within with bonding conductors sized according to NFPA 70, Article 250.122, "Size of Equipment Grounding Conductors."

1.13 CABLE INSTALLATION

A. Install cables only when each cable tray run has been completed and inspected.

B. Fasten cables on horizontal runs with cable clamps or cable ties according to NEMA VE 2. Tighten clamps only enough to secure the cable, without indenting the cable jacket. Install cable ties with a tool that includes an automatic pressure-limiting device.

C. Fasten cables on vertical runs to cable trays every 18 inches.

D. Fasten and support cables that pass from one cable tray to another or drop from cable trays to equipment enclosures. Fasten cables to the cable tray at the point of exit and support cables independent of the enclosure. The cable length between cable trays or between cable tray and enclosure shall be no more than 72 inches.

E. Tie MI cables down every 36 inches where required to provide a 2-hour fire rating and every 72 inches elsewhere.

F. In existing construction, remove inactive or dead cables from cable trays.

1.14 CONNECTIONS

A. Remove paint from all connection points before making connections. Repair paint after the connections are completed.

B. Connect pathways to cable trays according to requirements in NEMA VE 2 and NEMA FG 1.

1.15 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. After installing cable trays and after electrical circuitry has been energized, survey for compliance with requirements.
2. Visually inspect cable insulation for damage. Correct sharp corners, protuberances in cable trays, vibrations, and thermal expansion and contraction conditions, which may cause or have caused damage.
3. Verify that the number, size, and voltage of cables in cable trays do not exceed that permitted by NFPA 70. Verify that communications or data-processing circuits are separated from power circuits by barriers or are installed in separate cable trays.
4. Verify that there are no intruding items such as pipes, hangers, or other equipment in the cable tray.
5. Remove dust deposits, industrial process materials, trash of any description, and any blockage of tray ventilation.
6. Visually inspect each cable tray joint and each ground connection for mechanical continuity. Check bolted connections between sections for corrosion. Clean and retorque in suspect areas.
7. Check for improperly sized or installed bonding jumpers.
8. Check for missing, incorrect, or damaged bolts, bolt heads, or nuts. When found, replace with specified hardware.
9. Perform visual and mechanical checks for adequacy of cable tray grounding; verify that all takeoff raceways are bonded to cable trays. Test entire cable tray system for continuity. Maximum allowable resistance is 1 ohm.

B. Prepare test and inspection reports.

1.16 PROTECTION

A. Protect installed cable trays and cables.

1. Install temporary protection for cables in open trays to safeguard exposed cables against falling objects or debris during construction. Temporary protection for cables and cable tray can be constructed of wood or metal materials and shall remain in place until the risk of damage is over.

2. Repair damage to galvanized finishes with zinc-rich paint recommended by cable tray manufacturer.
3. Repair damage to paint finishes with matching touchup coating recommended by cable tray manufacturer.

END OF SECTION 270536

SECTION 270543 - UNDERGROUND PATHWAYS AND STRUCTURES FOR COMMUNICATION SYSTEMS

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 conduit and fittings, including GRC and PVC-coated GRC.
2. Rigid nonmetallic duct.
3. Duct accessories, including rigid innerduct and fabric innerduct.
4. Precast concrete handholes.
5. Polymer concrete handholes and boxes with polymer concrete cover.
6. Utility structure accessories.

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 conduit.

E. IMC: Intermediate metal conduit.

F. RNC: Rigid nonmetallic conduit.

G. 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 and conduits and their accessories, including elbows, end bells, bends, fittings, duct spacers and solvent cement.
3. Include accessories for, handholes, and boxes, and other utility structures.
4. Include underground-line warning tape.

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 location and duct size.
c. Include reinforcement details.
d. Include grounding details.
e. Include dimensioned locations of cable rack inserts, pulling-in and lifting irons, and sumps.
f. 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 location and duct size.
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. Duct and Duct-Bank Coordination Drawings: 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. Product Certificates: For concrete and steel used in precast concrete handholes, as required by ASTM C 858.

C. Qualification Data: For professional engineer and testing agency responsible for testing nonconcrete handholes and boxes.

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, 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. Ground Water: Assume ground-water level is 36 inches below ground surface unless a higher water table is noted on Drawings.

1.9 METAL CONDUITS AND FITTINGS

A. GRC: Comply with ANSI C80.1 and UL 6.

B. PVC-Coated Steel Conduit: PVC-coated GRC IMC.

1. Comply with NEMA RN 1.
2. Coating Thickness: 0.040 inch, minimum.

C. 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-C and TIA-758-C.

1.10 RIGID NONMETALLIC DUCTS

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. Underground Plastic Utilities Duct: Type EB-20 PVC RNC, complying with NEMA TC 6 & 8, ASTM F-512, and UL 651, with matching fittings complying with NEMA TC 9 by same manufacturer as duct.

C. General Requirements for Nonmetallic Ducts 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-C and TIA-758-C.

1.11 DUCT ACCESSORIES

A. Fabric Innerduct: Continuous, polyester, multi-pocket fabric innerduct, with internal pull tape and tracer wire.

B. 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.

C. Underground-Line Warning Tape: Underground-line warning tape specified in Section 270553 "Identification for Communications Systems."

1.12 PRECAST CONCRETE HANDHOLES AND BOXES

A. Description: Monolithically poured, factory-fabricated, reinforced-concrete walls and bottom unless open-bottom enclosures are indicated. Frame and cover shall form top of enclosure and shall have load rating consistent with that of handhole or box.

B. Comply with ASTM C 858 for design and manufacturing processes.

C. Frame and Cover: Weatherproof cast-iron frame, with cast-iron cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.

D. Frame and Cover: Weatherproof steel frame, with steel cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.

E. Frame and Cover: Weatherproof steel frame, with hinged steel access door assembly with tamper-resistant, captive, cover-securing bolts.

1. Cover Hinges: Concealed, with hold-open ratchet assembly.
2. Cover Handle: Recessed.

F. Frame and Cover: Weatherproof aluminum frame, with hinged aluminum access door assembly with tamper-resistant, captive, cover-securing bolts.

1. Cover Hinges: Concealed, with hold-open ratchet assembly.
2. Cover Handle: Recessed.

G. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.

H. Cover Legend: Molded lettering, "COMMUNICATIONS."

I. Configuration: Units shall be designed for flush burial and have integral closed bottom unless otherwise indicated.

J. Extensions and Slabs: Designed to mate with bottom of enclosure, and made of same material as enclosure.

1. Extension shall provide increased depth of 12 inches.
2. Slab: Same dimensions as bottom of enclosure, and arranged to provide closure.

K. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.

L. Knockout Panels: Precast openings in walls, arranged to match dimensions and elevations of approaching duct and duct banks, plus an additional 6 inches (150 mm) vertically and horizontally to accommodate alignment variations.

1. Knockout panels shall be located no less than 6 inches from interior surfaces of walls, floors, or frames and covers of handholes, but close enough to corners to facilitate racking of cables on walls.
2. Knockout panel opening shall have cast-in-place, welded-wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct banks.
3. Knockout panel openings shall be framed with at least two additional No. 3 steel reinforcing bars in concrete around each opening.
4. Knockout panels shall be 1-1/2 to 2 inches thick.

M. Duct Entrances in Handhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.

1. Type and size shall match fittings to duct or conduit to be terminated.
2. Fittings shall align with elevations of approaching duct and be located near interior corners of handholes to facilitate racking of cable.

N. Handholes 12 inches wide by 24 inches long and larger shall have inserts for cable racks and pulling-in irons installed before concrete is poured.

1.13 POLYMER CONCRETE HANDHOLES AND BOXES WITH POLYMER CONCRETE COVER

A. Description: Molded of sand and aggregate, bound together with a polymer resin, and reinforced with steel or fiberglass or a combination of the two.

B. Standard: Comply with SCTE 77. Comply with tier requirements in "Underground Enclosure Application" Article.

C. Color: Gray.

D. Configuration: Units shall be designed for flush burial and have integral closed bottom unless otherwise indicated.

E. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.

F. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.

G. Cover Legend: Molded lettering, "COMMUNICATIONS."

H. Direct-Buried Wiring Entrance Provisions: Knockouts equipped with insulated bushings or end-bell fittings, selected to suit box material, sized for wiring indicated, and arranged for secure, fixed installation in enclosure wall.

I. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering duct for secure, fixed installation in enclosure wall.

J. Handholes 12 inches wide by 24 inches long and larger shall have factory-installed inserts for cable racks and pulling-in irons.

1.14 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 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.

1.15 PREPARATION

A. Coordinate layout and installation of duct, duct bank, manholes, 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 runs 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 Section 311000 "Site Clearing." Remove and stockpile topsoil for reapplication according to Section 311000 "Site Clearing."

1.16 UNDERGROUND DUCT APPLICATION

A. Duct for Communications: Type EPC-40-PVC RNC, in direct-buried duct bank unless otherwise indicated.

B. Underground Duct Crossing Driveways, Roadways: Type EPC-40-PVC RNC, encased in reinforced concrete.

C. Stub-Ups for Communications: Concrete-encased GRC.

1.17 UNDERGROUND ENCLOSURE APPLICATION

A. Handholes and Boxes for Communications:

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. Units in Sidewalk and Similar Applications with a Safety Factor for Nondeliberate Loading by Vehicles: Precast concrete, AASHTO HB 17, H-10 structural load rating.
4. Units Subject to Light-Duty Pedestrian Traffic Only: Polymer concrete, structurally tested according to SCTE 77 with 3000-lbf (13 345-N) vertical loading.
5. Cover design load shall not exceed the design load of the handhole or box.

1.18 EARTHWORK

A. Excavation and Backfill: Comply with Section 312000 "Earth Moving," but do not use heavy-duty, hydraulic-operated, compaction equipment.

B. Restoration: Replace area immediately after backfilling is completed or after construction in immediate area is complete.

C. Restore surface features at areas disturbed by excavation, and re-establish original grades unless otherwise indicated.

D. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Comply with Section 329200 "Turf and Grasses" and Section 329300 "Plants."

E. Cut and patch existing pavement in the path of underground duct, duct bank, and utility structures according to the "Cutting and Patching" Article in Section 017300 "Execution."

1.19 DUCT AND DUCT-BANK INSTALLATION

A. Where indicated on Drawings, install duct, spacers, and accessories into the duct configuration shown. Duct installation requirements in this Section also apply to duct bank.

B. Install duct and duct bank according to NEMA TCB 2 and TIA-758-C.

C. Slope: Pitch duct and duct bank a minimum slope of 1:100 down toward manholes and handholes and away from buildings and equipment. Slope duct and duct bank from a high point in runs 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 (1200 mm) 12.5 feet (4 m) 25 feet (7.5 m), both horizontally and vertically, at other locations unless otherwise indicated.

1. Duct and duct banks 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 ducts do not lie in same plane.

F. Installation Adjacent to High-Temperature Steam Lines: Where duct or duct banks are installed parallel to underground steam lines, perform calculations showing the duct or duct bank 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 or duct bank 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 6 inches (150 mm) o.c. for 4-inch (100-mm) 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 and duct banks, 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 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 or duct bank, 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 slope away from the building or forming a trap in the duct. Use fittings manufactured for RNC duct-to-GRC conduit

transition. Install GRC penetrations of building walls as specified in Section 270544 "Sleeves and Sleeve Seals for Communications Pathways and Cabling."

J. Sealing: Provide temporary closure at terminations of duct that has cables pulled. Seal spare ducts at terminations. Use sealing compound and plugs to withstand at least 15-psig (1.03-MPa) hydrostatic pressure.

K. Innerduct: Install immediately after mandreling duct. Provide three innerducts per duct.

L. Pulling Cord: Install 200-lbf- (1000-N-m) test nylon cord in empty duct and innerduct.

M. Concrete-Encased Duct and Duct Bank:

1. Excavate trench bottom to provide firm and uniform support for duct or duct bank. Prepare trench bottoms as specified in Section 312000 "Earth Moving" for pipes less than 6 inches in nominal diameter.
2. Width: Excavate trench 12 inches wider than duct or duct bank on each side.
3. Width: Excavate trench 3 inches wider than duct or duct bank on each side.
4. Depth: Install top of duct and duct bank 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 and duct bank on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.
6. 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.
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 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 duct or duct bank.
8. Elbows: Use manufactured duct elbows for stub-ups, at building entrances, and at changes of direction in duct run unless otherwise indicated. Extend concrete 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 GRC to duct 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 flush with minimum 4 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 flush with minimum 4 inches above finished floor and no less than 3 inches from conduit side to edge of wall.

10. Reinforcement: Reinforce concrete-encased duct and duct bank where they cross disturbed earth and where indicated. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.
11. Forms: Use trench walls to form side walls of duct and 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 ducts, and 4 inches between power and communications duct.
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 recommendations, 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 033000 "Cast-in-Place Concrete." Place concrete carefully during pours to prevent voids under and between ducts and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto duct. Allow concrete to flow to center of bank and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-bank application.

N. Direct-Buried Duct and Duct Banks:

1. Excavate trench bottom to provide firm and uniform support for duct and duct bank. Comply with requirements in Section 312000 "Earth Moving" for preparation of trench bottoms for duct less than 6 inches in nominal diameter.
2. Install duct with a minimum of 3 inches between duct for like services and 6 inches between power and signal duct.
3. Width: Excavate trench 12 inches wider than duct or duct bank on each side.
4. Width: Excavate trench 3 inches wider than duct or duct bank on each side.
5. Depth: Install top of duct or duct bank at least 36 inches below finished grade unless otherwise indicated.
6. Set elevation of bottom of duct or duct bank below frost line.
7. Support duct on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.
8. 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 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 duct or duct bank.

9. Elbows: Install manufactured duct elbows for stub-ups, at building entrances through floor, and at changes of direction in duct unless otherwise indicated. Encase elbows for stub-ups throughout length of elbow. Extend encasement minimum of 36 inches beyond elbow joints.
10. Install manufactured GRC elbows for stub-ups, at building entrances, and at changes of direction in duct.
    a. Couple GRC to duct with adapters designed for this purpose, and encase coupling with 3 inches of concrete.
    b. For equipment mounted on outdoor bases, extend GRC horizontally a minimum of 60 inches from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.
11. After installing first tier of duct, backfill and compact. Start at tie-in point and work toward end of duct run, leaving duct 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 duct 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 of 3 inches of sand as a bed for duct and duct bank. Place sand to a minimum of 6 inches above top level of duct and duct bank.
    b. Place minimum of 6 inches of engineered fill above concrete encasement of duct bank.

O. Underground-Line Warning Tape: Bury non-conducting underground-line warning tape specified in Section 270553 "Identification for Communication Systems" no less than 12 inches above all concrete-encased duct and duct bank 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.

1.20 INSTALLATION OF CONCRETE MANHOLES, HANDHOLES, AND BOXES

A. Cast-in-Place Manhole Installation:

1. Finish interior surfaces with a smooth-troweled finish.
2. Knockouts for Future Duct Connections: Form and pour concrete knockout panels 1-1/2 to 2 inches thick, arranged as indicated.
3. Comply with requirements in Section 033000 "Cast-in-Place Concrete" for cast-in-place concrete, formwork, and reinforcement.

B. Precast Concrete Handhole and Manhole 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 (25-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.

C. Elevations:

1. Manhole Roof: Install with rooftop at least 15 inches below finished grade.
2. Manhole Frame: In paved areas and traffic ways, set frames flush with finished grade. Set other manhole frames 1 inch above finished grade.
3. Install handholes with bottom below frost line, < below grade.
4. Handhole Covers: In paved areas and trafficways, set surface flush with finished grade. Set covers of other handholes 1 inch above finished grade.
5. Where indicated, cast handhole cover frame integrally with handhole structure.

D. Drainage: Install drains in bottom of manholes where indicated. Coordinate with drainage provisions indicated.

E. 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.

F. Waterproofing: Apply waterproofing to exterior surfaces of handhole after concrete has cured at least three days. Waterproofing materials and installation are specified in Section 071353 "Elastomeric 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.

G. Dampproofing: Apply dampproofing to exterior surfaces of handholes after concrete has cured at least three days. Dampproofing materials and installation are specified in Section 071113 "Bituminous Dampproofing." After duct has been connected and grouted, and before backfilling, dampproof joints and connections, and touch up abrasions and scars. Dampproof exterior of manhole chimneys after mortar has cured at least three days.

H. 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.

I. Field-Installed Bolting Anchors in Concrete handholes: Do not drill deeper than 3-7/8 inches for manholes and 2 inches for handholes, for field-installed anchor bolts installed. Use a minimum of two anchors for each cable stanchion.

1.21 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 duct bank, 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 trafficways, 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, 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 (20 kPa), 28-day strength, complying with Section 033000 "Cast-in-Place Concrete," with a troweled finish.
2. Dimensions: 10 inches wide by 12 inches deep (250 mm wide by 300 mm deep).

1.22 GROUNDING

A. Ground underground duct, duct bank, and utility structures according to Section 270526 "Grounding and Bonding for Communications Systems."

1.23 FIELD QUALITY CONTROL

A. Perform the following tests and inspections and prepare test reports:

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 270526 "Grounding and Bonding for Communications Systems."

B. Correct deficiencies and retest as specified above to demonstrate compliance.

1.24 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.

B. Clean internal surfaces of manholes, including sump.

1. Sweep floor, removing dirt and debris.
2. Remove foreign material.

END OF SECTION 270543

SECTION 270544 - SLEEVES AND SLEEVE SEALS FOR COMMUNICATIONS PATHWAYS AND CABLING

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 pathway 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 078413 "Penetration 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.

1.4 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-steel sheet.
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.

1.5 SLEEVE-SEAL SYSTEMS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and pathway 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.

1.6 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.

1.7 GROUT

A. Description: Nonshrink; 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 (34.5-MPa), 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

1.8 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, nonshrinking foam.

1.9 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 pathway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 079200 "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 pathway or cable unless sleeve seal is to be installed or unless seismic criteria require different clearance.
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 pathways 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 pathway or cable and sleeve for installing sleeve-seal system.

1.10 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at pathway entries into building.

B. Install type and number of sealing elements recommended by manufacturer for pathway or cable material and size. Position pathway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pathway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

1.11 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 270544

SECTION 270548.16 - SEISMIC CONTROLS FOR COMMUNICATIONS SYSTEMS

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. Restraint channel bracings.
2. Restraint cables.
3. Seismic-restraint accessories.
4. Mechanical anchor bolts.
5. Adhesive anchor bolts.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.

    a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an agency acceptable to authorities having jurisdiction.
    b. Annotate to indicate application of each product submitted and compliance with requirements.

B. Delegated-Design Submittal: For each seismic-restraint device.

1. Include design calculations and details for selecting seismic restraints complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
2. Design Calculations: Calculate static and dynamic loading caused by equipment weight, operation, and seismic forces required to select seismic restraints and for designing vibration isolation bases.

    a. Coordinate design calculations with wind load calculations required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.

3. Seismic -Restraint Details:

    a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
    b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment

locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.

c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.

d. Preapproval and Evaluation Documentation: B an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of seismic bracing for electrical components with other systems and equipment in the vicinity, including other supports and seismic restraints. Communications components include:

1. Uninterruptible power supplies.
2. Racks.
3. Frames.
4. Cabinets.
5. Cable tray.
6. Conduits.

B. Qualification Data: For professional engineer and testing agency.

C. Welding certificates.

D. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated and that is acceptable to authorities having jurisdiction.

B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

C. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis. They shall bear anchorage preapproval from OSHPD in addition to preapproval, showing maximum seismic-restraint ratings, by ICC-ES or another agency acceptable to authorities having jurisdiction. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) that support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

E. Comply with NFPA 70.

1.6 PERFORMANCE REQUIREMENTS

A. Seismic-Restraint Loading: Per requirements indicated on the structural plans.

1.7 RESTRAINT CHANNEL BRACINGS

A. Description: MFMA-4, shop- or field-fabricated bracing assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end, with other matching components, and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

1.8 RESTRAINT CABLES

A. Restraint Cables: ASTM A 603 galvanized-steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; with a minimum of two clamping bolts for cable engagement.

1.9 SEISMIC-RESTRAINT ACCESSORIES

A. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.

B. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid channel bracings and restraint cables.

C. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings and matched to type and size of anchor bolts and studs.

D. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings and matched to type and size of attachment devices used.

E. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

1.10 MECHANICAL ANCHOR BOLTS

A. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

1.11 ADHESIVE ANCHOR BOLTS

A. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing PVC or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

1.12 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for reinforcement and cast-in-place anchors to verify actual locations before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

1.13 APPLICATIONS

A. Multiple Raceways or Cables: Secure raceways and cables to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.

B. Hanger-Rod Stiffeners: Install hanger-rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods caused by seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

1.14 SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete."

B. Equipment and Hanger Restraints:

1. Install resilient, bolt-isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
2. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

E. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

F. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid pre-stressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

1.15 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in runs of raceways, cables, wireways, cable trays, and busways where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where connection is terminated to equipment that is anchored to a different structural element from the one supporting them as they approach equipment.

1.16 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless post connection testing has been approved), and with at least seven days' advance notice.
3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.

5. Test to 90 percent of rated proof load of device.

B. Seismic controls will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

1.17 ADJUSTING

A. Adjust restraints to permit free movement of equipment within normal mode of operation.

END OF SECTION 270548.16

SECTION 270553 - IDENTIFICATION FOR COMMUNICATIONS SYSTEMS

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. 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:

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.

1.4 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.

1.5 COLOR AND LEGEND REQUIREMENTS

A. Raceways: Colored raceways are required. Refer to section 260533 for requirements.

B. Equipment Identification Labels:

1. Black letters on a white field.

1.6 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.

B. Snap-Around Labels: Slit, pre-tensioned, flexible, preprinted, color-coded acrylic sleeves, with diameters sized to suit diameters of raceway or cable they identify, that stay in place by gripping action.

C. Self-Adhesive Wraparound Labels: Preprinted, 3-mil-thick, polyester flexible labels with acrylic pressure-sensitive adhesive.

1. Self-Lamination: Clear; UV-, weather- and chemical-resistant; self-laminating protective shields over the legend. Labels sized such that the clear shield overlaps the entire printed legend.
2. Marker for Labels: Permanent, waterproof black ink marker recommended by tag manufacturer.
3. Marker for Labels: Machine-printed, permanent, waterproof black ink recommended by printer manufacturer.

D. Self-Adhesive Labels: Polyester, thermal, transfer-printed, 3-mil-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 for raceway and conductors.
b. 3-1/2 by 5 inches for equipment.
c. As required by authorities having jurisdiction.

1.7 BANDS AND TUBES

A. Snap-Around, Color-Coding Bands: Slit, pre-tensioned, flexible, solid-colored acrylic sleeves, 2 inches long, with diameters sized to suit diameters of raceway or cable they identify, that stay in place by gripping action.

1.8 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".

1.9 SIGNS

A. Baked-Enamel Signs:

1. Preprinted aluminum signs, high-intensity reflective, punched or drilled for fasteners, with colors, legend, and size required for application.
2. 1/4-inch grommets in corners for mounting.
3. Nominal Size: 7 by 10 inches.

B. Metal-Backed Butyrate Signs:

1. 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.
2. 1/4-inch grommets in corners for mounting.
3. Nominal Size: 10 by 14 inches.

C. Laminated-Acrylic or Melamine-Plastic Signs:

1. Engraved legend.
2. 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 (6.4-mm) grommets in corners for mounting.
e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

1.10 CABLE TIES

A. 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.

B. 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.

C. 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.

1.11 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.

1.12 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.

1.13 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. 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.
3. Provide label 6 inches from cable end.

I. Snap-Around Labels:

1. Secure tight to surface at a location with high visibility and accessibility.
2. Provide label 6 inches from cable end.

J. Self-Adhesive Wraparound Labels:

1. Secure tight to surface at a location with high visibility and accessibility.
2. Provide label 6 inches from cable end.

K. 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.

L. Snap-Around, Color-Coding Bands: Secure tight to surface at a location with high visibility and accessibility.

M. 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.

N. Cable Ties: General purpose, except as listed below:

1. Outdoors: UV-stabilized nylon.
2. In Spaces Handling Environmental Air: Plenum rated.

1.14 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. Equipment Room Labeling:

1. Racks, Frames, and Enclosures: Identify front and rear of each with self-adhesive labels containing equipment designation.
2. Data Outlets: Label each outlet with a self-adhesive label indicating the following, in the order listed:

a. Room number being served.
b. Colon.
c. Faceplate number.

F. Backbone Cables: Label each cable with a vinyl-wraparound label snap-around label, self-adhesive wraparound 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.

G. Horizontal Cables: Label each cable with a vinyl-wraparound label snap-around label self-adhesive wraparound label indicating the following, in the order listed:

1. Room number.
2. Colon.
3. Faceplate number.

H. Locations of Underground Lines: Underground-line warning tape for copper, coaxial, hybrid copper/fiber, and optical-fiber cable.

I. Instructional Signs: Self-adhesive labels.

J. Warning Labels for Indoor Cabinets, Boxes, and Enclosures: Baked-enamel warning signs.

1. Apply to exterior of door, cover, or other access.

K. Equipment Identification Labels:

1. Indoor Equipment: Baked-enamel signs.
2. Outdoor Equipment: Laminated-acrylic or melamine-plastic sign.
3. 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 271100 - COMMUNICATIONS EQUIPMENT ROOM FITTINGS

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. Backboards.
2. Boxes, enclosures, and cabinets.

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. RCDD: Registered communications distribution designer.

D. Service Provider: The operator of a telecommunications transmission service delivered through access provider facilities.

E. TGB: Telecommunications grounding bus bar.

F. 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, and furnished specialties and accessories.

B. Shop Drawings: For communications equipment room fittings. 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 grounding bus bar and its mounting detail showing standoff insulators and wall mounting brackets.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified layout technician, installation supervisor, and field inspector.

B. Seismic Qualification Data: Certificates, 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. Base certification on the maximum number of components capable of being mounted in each rack type. Identify components on which certification is based.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: Cabling installer must have personnel certified by BICSI on staff.

1. Layout Responsibility: Preparation of Shop Drawings shall be under direct supervision of Technician.
2. Installation Supervision: Installation shall be under direct supervision of Technician, 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 Technician to perform the on-site inspection.

1.7 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Equipment 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 when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.8 BACKBOARDS

A. Backboards: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches.

B. Backboard Paint: Pre-painted.

1.9 BOXES, ENCLOSURES, AND CABINETS

A. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets shall be listed and labeled for intended location and use.

B. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

C. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, Type FD, aluminum, with gasketed cover.

D. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.

E. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

F. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, cast aluminum with gasketed cover.

G. Box extensions used to accommodate new building finishes shall be of same material as recessed box.

H. Device Box Dimensions: 4 inches square by 2-1/8 inches deep.

I. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1 with continuous-hinge cover with flush latch unless otherwise indicated.

1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
2. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

J. Cabinets:

1. NEMA 250, Type 1 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.

1.10 ENTRANCE FACILITIES

A. Contact telecommunications service provider and arrange for installation of demarcation point, protected entrance terminals, and a housing when so directed by service provider.

B. Comply with requirements in Section 270528 "Pathways for Communications Systems" for materials and installation requirements for underground pathways.

1.11 INSTALLATION

A. Comply with NECA 1.

B. Comply with BICSI's "Telecommunications Distribution Methods Manual" for layout of communications equipment spaces.

C. Comply with BICSI's "Information Technology Systems Installation Methods Manual" for installation of equipment in communications equipment spaces.

D. Coordinate layout and installation of communications equipment in tracks and in room. Coordinate service entrance configuration with service provider.

1. Meet jointly with systems providers, equipment suppliers, and Owner to exchange information and agree on details of equipment configurations and installation interfaces.
2. Record agreements reached in meetings and distribute them to other participants.
3. Adjust configurations and locations of distribution frames, cross-connects, and patch panels in equipment rooms to accommodate and optimize configurations and space requirements of communications equipment.
4. Adjust configurations and locations of equipment with distribution frames, cross-connects, and patch panels of cabling systems of other communications, electronic safety and security, and related systems that share space in equipment room.

E. Coordinate location of power raceways and receptacles with locations of communications equipment requiring electrical power to operate.

F. Backboards:

1. Install from 6 inches to 8 feet, 6 inches above finished floor. If plywood is fire rated, ensure that fire-rating stamp is visible after installation.
2. Paint all sides of backboard with two coats of paint, leaving fire rating stamp visible.
3. Comply with requirements for backboard installation in BICSI's "Information Technology Systems Installation Methods Manual" and TIA-569-D.

1.12 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 270544 "Sleeves and Sleeve Seals for Communications Pathways and Cabling."

1.13 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping."

B. Comply with TIA-569-D, Annex A, "Firestopping."

C. Comply with BICSI's "Information Technology Systems Installation Methods Manual," "Firestopping Practices" Ch.

END OF SECTION 271100

SECTION 283111 - DIGITAL, ADDRESSABLE FIRE-ALARM SYSTEM

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 fire alarm systems, including manual stations, detectors, signal equipment, controls, and devices. Note that this is a performance based specification. Equipment/device quantities and locations indicated are diagrammatic. Design of the fire alarm system, including device placements, selection and quantities, shall be by a NICET level III designer in accordance with the requirements of the New Mexico State Fire Marshall's Office (NMSFMO). The design shall be approved by the NMSFMO. Refer to additional submission requirements below. The basis of design is Notifier Onyxworks (or approved equal).

B. Section Includes:

1. Fire-alarm control unit.
2. Manual fire-alarm boxes.
3. System smoke detectors.
4. Heat detectors.
5. Notification appliances.
6. Magnetic door holders.
7. Remote annunciator.
8. Graphic annunciator.
9. Addressable interface device.
10. Digital alarm communicator transmitter.
11. Network communications.
12. 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.

F. VESDA: Very Early Smoke-Detection Apparatus.

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, 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.
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. Provide program report showing that air-sampling detector pipe layout balances pneumatically within the airflow range of the air-sampling detector.
12. 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.
    f. Show air-sampling detector pipe routing.

13. Include voice/alarm signaling-service equipment rack or console layout, grounding schematic, amplifier power calculation, and single-line connection diagram.

14. 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.

C. General Submittal Requirements:

1. Submittals shall be approved by authorities having jurisdiction 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, Level IV 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. Submission to Authorities Having Jurisdiction: In addition to routine submission of the above material, make an identical submission to the authorities having jurisdiction. Shop drawing submission to the New Mexico State Fire Marshall (NMSFM) shall meet all requirements stated in the New Mexico State Fire Marshall's Office Plans Review Submittal Requirements and Information publication. Include Professional Engineer's seal, and design by a NICET Level III technician as part of the preparation and submission of the shop drawings. Upon receipt of comments from the authorities having jurisdiction, submit them for review. Resubmit if required to make clarifications or revisions to obtain approval. Do not proceed with any work prior to approval from the NMSFM

C. 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.

D. Field quality-control reports.

E. 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 017823 "Operation and Maintenance Data," 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. Air-sampling system sample port locations and modeling program report showing layout meets performance criteria.
g. Record copy of site-specific software.
h. 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.

i. Manufacturer's required maintenance related to system warranty requirements.
j. 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.

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 fewer than one unit.
2. Lamps for Strobe Units: Quantity equal to 10 percent of amount installed, but no fewer than one unit.
3. Smoke Detectors, Fire Detectors, and Flame Detectors: Quantity equal to 10 percent of amount of each type installed, but no fewer than one unit of each type.
4. Detector Bases: Quantity equal to two percent of amount of each type installed, but no fewer than one unit of each type.
5. Keys and Tools: One extra set for access to locked or tamperproofed components.
6. Audible and Visual Notification Appliances: One 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.
8. Filters for Air-Sampling Detectors: Quantity equal to two percent of amount of each type installed, but no fewer than one unit of each type.
9. Air-Sampling Fan: Quantity equal to one for every five detectors, but no fewer than one unit of each type.

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 by a UL-listed alarm company.

E. NFPA Certification: Obtain certification according to NFPA 72 in the form of a placard by an FM Global-approved alarm company.

F. NFPA Certification: Obtain certification according to NFPA 72.

1.9 SEQUENCING AND SCHEDULING

A. Existing Fire-Alarm Equipment: Maintain existing equipment fully operational until new equipment has been tested and accepted. As new equipment is installed, label it "NOT IN SERVICE" until it is accepted. Remove labels from new equipment when put into service, and label existing fire-alarm equipment "NOT IN SERVICE" until removed from the building.

B. Equipment Removal: After acceptance of new fire-alarm system, remove existing disconnected fire-alarm equipment and wiring.

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.

1.11 SYSTEM DESCRIPTION

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Notifier (or Approved Equal)

B. Noncoded, UL-certified addressable system, with multiplexed signal transmission and chime/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.

1.12 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. Automatic sprinkler system water flow.
7. Pre-action system.
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.

2. Identify alarm and specific initiating device at fire-alarm control unit, connected network control panels, off-premises network control panels, 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 pre-action system.
12. Activate emergency lighting control.
13. Activate emergency shutoffs for gas and fuel supplies.
14. Record events in the system memory.
15. Record events by the system printer.
16. 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. Fire pump running.
6. Fire-pump loss of power.
7. Fire-pump power phase reversal.
8. Independent fire-detection and -suppression systems.
9. User disabling of zones or individual devices.
10. 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, connected network control panels, off-premises network control panels, 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.

1.13 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."

1.14 FIRE-ALARM CONTROL UNIT

A. 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.

B. 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.

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, three line(s) of 80 characters, minimum.
2. Keypad: Arranged to permit entry and execution of programming, display, and control commands and to indicate control commands to be entered into the system for control of smoke-detector sensitivity and other parameters.

D. Initiating-Device, Notification-Appliance, and Signaling-Line Circuits:

1. Pathway Class Designations: NFPA 72, Class A.
2. Install no more than 100 addressable devices on each signaling-line circuit.
3. 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 port for PC configuration.
    d. One RS 232 port for VESDA HLI connection.
    e. One RS 232 port for voice evacuation interface.

E. 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.

F. 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.

G. Elevator Recall:

1. Elevator recall shall be initiated only by one of the following alarm-initiating devices:

    a. Elevator lobby detectors except the lobby detector on the designated floor.
    b. Smoke detector in elevator machine room.
    c. Smoke detectors in elevator hoistway.

2. Elevator controller shall be programmed to move the cars to the alternate recall floor if lobby detectors located on the designated recall floors are activated.
3. Water-flow alarm connected to sprinkler in an elevator shaft and elevator machine room shall shut down elevators associated with the location without time delay.

    a. Water-flow switch associated with the sprinkler in the elevator pit may have a delay to allow elevators to move to the designated floor.

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. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm station.

1. Status Annunciator: Indicate the status of various voice/alarm speaker zones and the status of firefighters' two-way telephone communication zones.
2. Preamplifiers, amplifiers, and tone generators shall automatically transfer to backup units, on primary equipment failure.

K. 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.

L. 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

signals, supervisory and digital alarm communicator 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.

M. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.

1. Batteries: Sealed lead calcium.

N. 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.

1.15 PREACTION SYSTEM

A. Initiate Pre-signal Alarm: This function shall cause an audible and visual alarm and indication to be provided at the FACP. Activation of an initiation device connected as part of a preaction system shall be annunciated at the FACP only, without activation of the general evacuation alarm.

1.16 MANUAL FIRE-ALARM BOXES

A. 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, 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, pull-lever 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.

1.17 SYSTEM SMOKE DETECTORS

A. 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 (8 or 11 deg C) 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 (57 or 68 deg C).
    c. Multiple levels of detection sensitivity for each sensor.
    d. Sensitivity levels based on time of day.

B. 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.).

C. 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. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector for smoke detection in HVAC system ducts.
4. Each sensor shall have multiple levels of detection sensitivity.
5. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
6. Relay Fan Shutdown: Fully programmable relay rated to interrupt fan motor-control circuit.

1.18 PROJECTED BEAM SMOKE DETECTORS

A. Projected Beam Light Source and Receiver: Designed to accommodate small angular movements and continue to operate and not cause nuisance alarms.

B. Detector Address: Accessible from fire-alarm control unit and able to identify the detector's location within the system and its sensitivity setting.

C. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:

1. Primary status.
2. Device type.
3. Present average value.
4. Present sensitivity selected.
5. Sensor range (normal, dirty, etc.).

1.19 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.

1.20 MULTICRITERIA DETECTORS

A. Mounting: Adapter plate for outlet box mounting.

B. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

C. Automatically adjusts its sensitivity by means of drift compensation and smoothing algorithms. The detector shall send trouble alarm if it is incapable of compensating for existing conditions.

D. Test button tests all sensors in the detector.

E. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:

1. Primary status.
2. Device type.
3. Present sensitivity selected.
4. Sensor range (normal, dirty, etc.).

F. Sensors: The detector shall be comprised of four sensing elements including a smoke sensor, a carbon monoxide sensor, an infrared sensor, and a heat sensor.

1. Smoke sensor shall be photoelectric type as described in "System Smoke Detectors" Article.
2. Carbon monoxide sensor shall be as described in "Carbon Monoxide Detectors" Article.
3. Heat sensor shall be as described in "Heat Detectors" Article.
4. Each sensor shall be separately listed according to requirements for its detector type.

1.21 HEAT DETECTORS

A. General Requirements for Heat Detectors: Comply with UL 521.

1. Temperature sensors shall test for and communicate the sensitivity range of the device.

B. Heat Detector, Combination Type: Actuated by either a fixed temperature of 135 deg F (57 deg C) or a rate of rise that exceeds 15 deg F (8 deg C) per minute unless otherwise indicated.

1. Mounting: Adapter plate for outlet box mounting.
2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

1.22 NOTIFICATION APPLIANCES

A. 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.

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.

B. Chimes, High-Level Output: Vibrating type, 81-dBA minimum rated output.

C. 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. 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.

D. 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.

1.23 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 (111-N) 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.

1.24 GRAPHIC ANNUNCIATOR

A. Graphic Annunciator Workstation: PC-based, with fire-alarm annunciator software with historical logging, report generation, and a graphic interface showing all alarm points in the system. PC with operating system software, minimum hard drive, digital display monitor, with wireless keyboard and mouse.

1.25 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.

1.26 ADDRESSABLE INTERFACE DEVICE

A. General:

1. Include address-setting means on the module.
2. Store an internal identifying code for control panel use to identify the module type.
3. Listed for controlling HVAC fan motor controllers.

B. Monitor Module: Microelectronic module providing a system address for alarm-initiating devices for wired applications with normally open contacts.

C. Integral Relay: Capable of providing a direct signal to elevator controller to initiate elevator recall and to circuit-breaker shunt trip for power shutdown.

1. Allow the control panel to switch the relay contacts on command.
2. Have a minimum of two normally open and two normally closed contacts available for field wiring.

D. Control Module:

1. Operate notification devices.
2. Operate solenoids for use in sprinkler service.

1.27 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.

1.28 NETWORK COMMUNICATIONS

A. Provide network communications for fire-alarm system according to fire-alarm manufacturer's written requirements.

B. Provide network communications pathway per manufacturer's written requirements and requirements in NFPA 72 and NFPA 70.

1.29 SYSTEM PRINTER

A. Printer shall be listed and labeled as an integral part of fire-alarm system.

1.30 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.

1.31 FIRE ALARM WIRE AND CABLE

A. General Wire and Cable Requirements: NRTL listed and labeled as complying with NFPA 70, Article 760.

B. Signaling Line Circuits: Twisted, shielded pair, size as recommended by system manufacturer.

1. Circuit Integrity Cable: Twisted shielded pair, NFPA 70, Article 760, Classification CI, for power-limited fire alarm signal service Type FPL. NRTL listed and labeled as complying with UL 1424 and UL 2196 for a two-hour rating.

C. Non-Power-Limited Circuits: Solid-copper conductors with 600-V rated, 75 deg C, color-coded insulation, and complying with requirements in UL 2196 for a two-hour rating.

1. Low-Voltage Circuits: No. 16 AWG, minimum, in pathway.
2. Line-Voltage Circuits: No. 12 AWG, minimum, in pathway.

1.32 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.

1.33 EQUIPMENT INSTALLATION

A. Comply with NFPA 72, NFPA 101, 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. Equipment Mounting: Install fire-alarm control unit on concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."

1. Install seismic bracing. Comply with requirements in Section 270548.16 "Seismic Controls for Communications Systems."
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 supported equipment.

D. Equipment Mounting: Install fire-alarm control unit on finished floor.

1. Comply with requirements for seismic-restraint devices specified in Section 270548.16 "Seismic Controls for Communications Systems."

E. 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."

F. 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.

G. 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 (910 mm) 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.

H. 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.

I. 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.

J. Air-Sampling Smoke Detectors: If using multiple pipe runs, the runs shall be pneumatically balanced.

K. Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location. Do not install smoke detectors in sprinklered elevator shafts.

L. 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.

M. 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.

N. 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.

O. 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.

P. Device Location-Indicating Lights: Locate in public space near the device they monitor.

Q. Antenna for Radio Alarm Transmitter: Mount to building structure where indicated. Use mounting arrangement and substrate connection that resists 100-mph (160-km/h) wind load with a gust factor of 1.3 without damage.

1.34 PATHWAYS

A. Pathways shall be installed in EMT.

B. Exposed EMT shall be painted red enamel.

1.35 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.
15. Supervisory connections at fire-pump power failure including a dead-phase or phase-reversal condition.
16. Supervisory connections at fire-pump engine control panel.

1.36 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 270553 "Identification for Communications Systems."

B. Install framed instructions in a location visible from fire-alarm control unit.

1.37 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.

1.38 FIELD QUALITY CONTROL

A. Field tests shall be witnessed by Architect.

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. Fire-alarm system will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports.

H. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.

I. 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.

1.39 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.

1.40 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.

1.41 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fire-alarm system.

END OF SECTION 283111

SECTION 31 0000 EARTHWORK

PART 1 - GENERAL

1.1 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 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.

1.2 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.

1.3 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 Investigation: Geotechnical Engineering Report Rhino Health Manufacturing Facilities – Phase II Church Rock, New Mexico. Prepared by GEOMAT, dated 4/7/2021. GEOMAT Project No. 212-3660

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. 2009 INTERNATIONAL BUILDING CODE (IBC)

1. Chapter 18 – Soils and Foundation

1.4 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.

1.5 SUBMITTALS

A. Fill and Backfill Materials: Gradation and moisture-density relationship for each material proposed for use as fill or backfill.

1.6 JOB CONDITIONS

A. Bench Marks: Protect bench marks on or adjacent to site from damage. If bench marks 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

2.1 SOIL MATERIALS

A. Base Course: Per Geotechnical Report.

B. 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 specified below. The plasticity index should be 10 (max) when tested in accordance with ASTM D-4318. Site soils may be used provided they meet all specified requirements. Otherwise, imported material or a combination of imported material and site material meeting specified requirements shall be used.

Sieve Size: Square Openings by Weight	Percent Passing
6”	100
3”	70-100
No. 4	50 - 100
No. 200	45 (max)

C. Pipe bedding material shall be processed natural material meeting the gradation requirements specified below. The plasticity index of the material used for pipe bedding shall not exceed 10 as determined by ASTM D4318.

Sieve Size: Square Openings by Weight	Percent Passing
1/2”	100
No. 4	50 - 100
No. 200	10 – 40

PART 3 – EXECUTION

3.1 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 herein for engineered fill and backfill.

D. Inspection: Cleared and excavated areas shall be inspected by Geotechnical Engineer prior to scarifying and placing fills.

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

F. Identify known underground utilities located by Owner. Protect stakes and flags installed by Owner.

G. Identify and flag surface and aerial utilities.

H. Notify utility companies to remove or relocate utilities as necessary.

I. Maintain and protect existing utilities which pass through site.

3.2 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 ground water 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 rain water 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.

F. Excavation for Structures:

1. 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.

G. Cold Weather Protection:

1. Protect excavation bottoms against freezing.

3.3 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 8-inch thickness and compacted to 95% of Standard Proctor Density (ASTM D-1557).

C. Subgrade Preparation:

1. The top 12 inches of in-place soil shall be plowed or scarified, processed to near optimum moisture (+/-3%) and compacted to at least 95% of maximum dry density (ASTM Designation: D-1557).

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:

E. All select fill material shall have a Plasticity Index of 10 (max) and should be placed in 8-inch maximum compacted lifts. All soil for fill shall be free of large rock (4” and larger) or other deleterious material and shall be processed to near optimum moisture (+/-3%) and compacted to a minimum of 95% of maximum dry density as determined by ASTM Designation D1557 and when tested in accordance with ASTM Designation: D 2922 prior to placing the next lift. 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.

1. The site shall be proof rolled to detect soft areas which should be removed and properly replaced.
2. Each lift shall be tested by a qualified Laboratory Technician under the supervision of a Registered Professional Engineer specializing in geotechnical studies.

3.4 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.

3.5 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.

3.6 DISPOSAL OF EXCESS AND WASTE MATERIALS

A. Remove waste materials, including unacceptable excavated material, trash and debris, and dispose of it off Owner's property.

3.7 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 200 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 310000

SECTION 312311 - EARTHWORK FOR BUILDING CONSTRUCTION

PART 1 - GENERAL

1.1 SECTION INCLUDES

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, within the building limits, complete in place in accordance with the Project Manual and Drawings.

1.2 RELATED REQUIREMENTS

A. Section 31 10 00 - Clearing

B. Section 07 26 00 - Under-Slab Vapor Retarder

C. General Foundation Notes on Drawings.

D. Project Soils Report – shall be completely reviewed and understood by the contractor. In case of conflict or omission, the Project Soils Report shall govern.

1.3 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.

1.4 REFERENCE STANDARDS

A. ASTM International, latest versions:

1. ASTM D1556 - Standard Test Method for Density of Soil in Place by the Sand-Cone Method
2. ASTM D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3 (2,700 kN-m/m3))
   OR
3. ASTM D4318 - Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
4. ASTM D6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

1.5 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.

1.6 TESTING AND INSPECTION

A. General: The Owner 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 Owner.

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.

1.7 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

2.1 STRUCTURAL FILL MATERIAL

A. Material shall consist of soils that conform to the following physical characteristics:

Sieve Size	Percent Passing
Sq. Openings	By Weight
6 inch	100
3 inch	100
No. 4	50-100
No. 200	50 Max

B. The plasticity index of the material to be used for fill or backfill, as determined in accordance with ASTM D 4318 shall not exceed 12 Max.

C. Maximum Expansive Potential (%) +1.5 (see geotechnical report for more details on measured sample)

D. Some of the clayey soils tested for this project have a plasticity index of greater than that recommended for structural (engineered fill). Blending of these soils with a material of lower plasticity may be required to meet the recommendations herein if these soils are to be used as structural (engineered) fill. The contractor should be responsible for determining the most appropriate method for providing the required structural (engineered) fill. (i.e. removal/replacement vs. blending) to meet the recommended requirements.

PART 3 - EXECUTION

3.1 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.

3.2 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 standard proctor 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 standard proctor as determined by ASTM D 1557.

3.3 EQUIPMENT AND METHODS

A. In areas not accessible to heavy equipment, distribute by and compact with hand operated vibratory compactors.

3.4 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.

3.5 COMPACTION

A. Fill shall be spread in layers not exceeding 8 inches, watered as necessary, and compacted. Moisture content at time of compaction shall plus/minus 2 percent of optimum moisture. A density of not less than 95 percent of standard proctor of maximum dry density shall be obtained within the building pads.

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
Miscellaneous backfill	90

3.6 MOISTURE CONTROL

A. The material, while being compacted, shall be within the moisture range of 2 percent below to 2 percent above optimum, well distributed throughout the layer.

3.7 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 6938. 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.

3.8 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.

3.9 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 6938	1 per 2500 square feet 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 6938	1 per each lift every 2500 square feet of surface	Immediately after placing, Conduct a minimum of 2 tests per section
		1 per each lift every 2500 square feet of fill	

END OF SECTION 312311

SECTION 321200 FLEXIBLE PAVING

PART 1 - GENERAL

1.1 RELATED REQUIREMENTS:

A. Any New Mexico Department of Transportation Standard Specifications sections referred to or noted on the drawings which pertain to flexible paving design, materials, preparation, and/or execution of this product shall supersede this section. All materials shall be as indicated on Drawings and shall comply with applicable New Mexico Department of Transportation specifications regarding source, quality, gradation, and mix design proportioning.

1.2 SUBMITTALS

A. Design Mix: Before any asphalt concrete paving or aggregate base course 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 New Mexico Department of Transportation 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.

1.3 REFERENCES

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° and rising.

PART 2 – PRODUCTS

2.1 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 New Mexico Department of Transportation standard specifications 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 Department of Transportation standards.

C. Asphalt Cement: Comply with AASHTO M-226/ASTM D 3381; AC-20, AR-80, viscosity grade.

D. Asphalt-Aggregate Mixture: per New Mexico Department of Transportation Standard Specifications

2.2 EQUIPMENT

A. 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

3.1 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.

3.2 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 New Mexico Department of Transportation Standard Specifications.
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.

3.3 ASPHALTIC CONCRETE PLACEMENT

A. 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 40° F and 50° F: 285° F.
2. When ambient temperature is between 50° F and 60° F: 280° F.
3. When ambient temperature is higher than 60° F: 275° F.

B. Place inaccessible and small areas by hand. Place each course to required grade, cross-section, and compacted thickness.

C. 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.

D. 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.

3.4 ROLLING AND COMPACTION

A. 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.

B. Compact mixture with hot hand tampers or vibrating plate compactors in areas inaccessible to rollers.

C. 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.

D. Second Rolling: Follow breakdown rolling as soon as possible, while mixture is hot. Continue second rolling until mixture has been thoroughly compacted.

E. 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.

F. 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.

G. 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.

3.5 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.

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 321200

SECTION 321300 CONCRETE PAVING

PART 1 - GENERAL

1.1 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.

1.2 REFERENCES

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

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

1.3 SUBMITTALS

A. Mix Design: For each concrete mix to be utilized.

B. Material certificates and test reports.

PART 2 PRODUCTS

2.1 STEEL REINFORCEMENT

A. The type of steel reinforcement shall be as shown on the drawings.

1. Plain-Steel Welded Wire Fabric: ASTM A 185, 6 inches' x 6 inches #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

2.2 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.

2.3 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

2.4 JOINTS, FILLERS, AND SEALANTS

A. Joint-Sealant Backer Materials: ASTM D5249, Non-Staining, compatible with joint substrates, sealants, primers, and other joint fillers; and approved for applications indicated by joint sealant manufacturer based on field experience and laboratory testing.

B. Joint Sealant: Non-priming, pourable self-leveling silicone sealant for concrete and asphalt.

1. Cold-Applied Joint Sealant ASTM D5893, self leveling silicone sealant. Crafco Inc. “Roadwaver Silicone-SL”; Dow Corning “888, or 890-SL”; Sonneborn “Sonomeric 1 Sealant”; Tremco “Vulkem 45”; and,
2. Hot-Applied Joint Sealant: ASTM D3405, Polymeric sealant. Crafco Inc. “ROADSAVER 22”; W.R. Meadows, Inc. “SEALTIGHT HI-SPEC”.

C. Joint Fillers: Resilient pre-molded bituminous impregnated fiberboard units complying with ASTM D 1751, asphalt-saturated cellulosic fiber, ASSHTO M 153, Type I: or ASTM D 1752, cork or self-expanding cork.

D. Exterior Concrete Sealant: Sonneborn “Kure-N-Seal 30” exterior acrylic sealer, or Euclid “Super Rez-Seal”.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Surface Preparation: Proofroll prepared subbase, per Section 31 0000 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.

3.2 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.

3.3 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.

3.4 QUALITY ASSURANCE

A. Manufacturer Qualifications: Manufacturer of ready-mixed concrete products complying with ASTM C 94 requirements for production facilities and equipment.

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 day's 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 321300

SECTION 331000 WATER UTILITIES

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. All work and materials in this Section shall be performed in accordance with the Contract Drawings and the New Mexico Public Works Association Standard 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. Pipes and appurtenances for potable water.

1.2 REFERENCES

A. 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. C900: Polyvinyl chloride (PVC) pressure pipe 4" through 12" for water.

B. ASTM:

1. A370: Mechanical Testing of steel products. A536: Ductile iron castings.
2. D1330: Rubber sheet gaskets.
3. D1598: Test for time-of-failure of plastic pipe under long-term hydrostatic pressure.
4. D1599: Test for short-term rupture strength of plastic pipe, tubing and fittings.
5. D1784: Polyvinyl chloride (PVC) compound and chlorinated polyvinyl chloride (PVC) compounds, rigid. D2241: Polyvinyl chloride (PVC) plastic pipe (SDR-DO).
6. D3139: Joints for plastic pressure pipes using flexible elastomeric seals.
7. E8: Tension testing for metallic materials

SUBMITTALS

A. Submittals per Section 01 33 00.

B. Product Requirement: Section 01 60 00.

C. Manufacturer's installation recommendations.

1.4 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.

1.5 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.

1.6 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

2.1 MATERIALS AND FABRICATION

A. Ductile Iron:

1. Pipe 3” and larger:
   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 200 psi.
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
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
2. Copper, Type K: ASTM B8
3. Minimum pressure rating: 150 psi.
4. Joints
   a. Compression fittings.
   b. Compatible with heavy duty copper service fittings.

2.2 APPURTENANCES

A. Resilient Wedge Gate Valves:

1. Size as shown on Drawings.
2. Mueller, Clow, Waterous, American Darling, Resilient Wedge Gate Valves or Engineer approved equivalent. Valves shall conform to AWWA C-509 and comply with its latest revisions.
3. 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.
4. The stem shall have two O-rings above and one O-ring below the collar. Stem seats must be replaceable with
5. 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
9. applied only at the valve manufacturer's facilities.
10. The bonnet bolts shall not be exposed to the environment or, alternatively, be in 316 stainless steel. 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

B. Reduced Pressure Backflow Preventer:

1. Body: Bronze ASTM B-61 and working parts.
2. Springs: Stainless steel.
3. Valve discs: Neoprene.
4. Diaphragm: Neoprene-coated cotton duck.
5. Minimum working pressure: 250 psi.
6. Hydrostatic test pressure: 350 psi.
7. Zurn Wilking's 375 DA or Engineer-approved equivalent.

C. 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. All valve boxes for plug valves shall be designed for integral installation of the required valve position indicator.
5. Cast iron boxes: Factory painted inside and out with manufacturer's recommended asphalt paint.
6. Cover marked "Water".

D. 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.

E. 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.

F. Tracer Wire:

1. Conductor shall be solid copper per ASTM B-1 or B-3.
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.

PART 3 – EXECUTION

3.1 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'-0" as measured from the established road grade or the surface of the permanent improvement to the top of the pipe.

C. Pipe Laying:

1. Proper implements, tools, and facilities shall be provided and used for the safe and convenient performance of the work.
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 New Mexico Public Works Association Standard 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.

I. Valves: Installed as shown on Drawings with valve boxes and joint restraint.

J. Fire hydrants: As indicated on Drawings with mechanically restrained joints.

3.2 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):

1. Medium: Water.
2. Perform test at 200 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 New Mexico Public Works Association Standard Specifications Section 801 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. Plug ends as required.
2. Water shall be applied by means of a pump connected to the pipe in a satisfactory manner. All air shall be expelled from the pipe prior to pressure testing.
3. 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 Public Works Association Standard Specifications Section 801:
4. 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.
5. 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.
6. Retest repaired joints, pipes and fittings until system is tight and test results are satisfactory to the Engineer. Pipe testing and preparation for use should strictly follow AWWA C605 Section. 7: Preparation for use. 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.

END OF SECTION 331000

SECTION 331500 GENERAL REQUIREMENTS FOR STEEL PIPING

PART 1 - GENERAL

1.1 DESCRIPTION

This section includes general requirements for materials, fabrication, installation, and testing of steel pipe.

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Specification Section 09 9000: PAINTING AND COATING.

B. Specification Section 09 9550: COLD APPLIED WAX TAPE COATING

1.3 SUBMITTALS

A. Submit shop drawings in accordance with Specification Section 01 3000: CONTRACTOR SUBMITTALS.

B. Submit materials list showing material of pipe and fittings with ASTM reference and grade. Submit manufacturer's certification of compliance with referenced standards, e.g., ASTM A 53, A 135, A 587, A 1018, AWWA C200.

C. For piping 36-inches and larger, submit piping layout drawings showing location and dimensions of pipe and fittings. Label or number each fitting or piece of pipe and provide the following information for each item:

1. Material of construction, with ASTM or API reference and grade.

2. Wall thickness of steel cylinder.

3. Mortar lining thickness.

4. Mortar armor coating thickness.

5. Paint prime coating, where prime coat is required.

6. Manufacturer's certificates of compliance with referenced pipe standards, e.g., ASTM A 53, ASTM A 135, AWWA C200.

7. Show weld sizes and dimensions of grooved-end collars, flanges, reinforcing collars, wrapper plates, and crotch plates.

D. Submit coating application test records for field measuring paint coating thickness and holiday detection for each pipe section and fitting. Describe repair procedures to be used.

PART 2 - MATERIALS

2.1 JOINTS

A. Provide plain-end pipe where flexible pipe couplings are to be provided. Provide lugs for thrust harnesses where shown in the drawings.

B. Where piping connects to wall pipes, meters, valves, or other equipment, the pipe ends shall match the ends of the wall pipes, meters, valves, or equipment.

2.2 FLANGES

A. Forged flange material shall conform to ASTM A 105, A 181, or A 182. Steel flange material shall conform to ASTM A 283 (Grade C or D), A 285 (Grade C), or A 36.

B. Determine the pressure class of the flanges based on the test pressures shown in the drawings. For test pressures 200 psi and less, use Class 150 flanges. For test pressures greater than 200 psi, use Class 300 flanges having the following facings unless otherwise indicated:

Test Pressure (psi)	**Size Range (inches)**	**Flange Facing**
200 to 375	48 and smaller	Flat

C. Class 150 flanges shall comply with AWWA C207, Class D or E as follows. Use welding neck flanges conforming to ANSI B16.5 where connecting to wrought steel elbows and tees. Flanges shall be flat faced. Use the following pressure classes of flanges based on the specified test pressures:

Test Pressure (psi)	**Pipe Size (inches)**	**Flange Pressure Class**
175 and less	4-12	Class D
176 to 275	4-12	Class E

D. Class 300 flanges 24 inches and smaller with flat faces shall comply with AWWA C207, Class F, or ANSI B16.5. Flanges 30 inches through 48 inches with flat faces shall comply with AWWA C207, Class F.

E. Provide flat-faced flanges as described above where connecting to cast-iron flanges and where otherwise indicated.

F. Blind flanges shall comply with AWWA C207, Table 7. Class 300 blind flanges shall be the same standard as the connecting flange. Where the mating pipe flange has a raised facing, the blind flange shall have the same facing.

2.3 BOLTS, NUTS, AND GASKETS FOR FLANGES

A. Gaskets for flat face and raised face flanges shall be 1/8-inch thick and shall be one of the following nonasbestos materials:

1. Acrylic or aramid fiber bound with nitrile. Products: Garlock "Bluegard," Klinger "Klingersil C4400," or equal. Gaskets shall be suitable for a pressure of 500 psi at a temperature of 400°F.

B. Bolts and nuts for Class 150 flanges (including AWWA C207, Class D) located indoors, and in vaults and structures shall be carbon steel, ASTM A 307, Grade B.

C. Bolts and nuts for buried or submerged Class 150 flanges shall be Type 304 stainless steel conforming to ASTM A 193 (Grade B8) for bolts and ASTM A 194 (Grade 8) for nuts.

D. Hex head machine bolts for use with lugged valves shall comply with ASTM A 193, Grade B7.

E. Fit shall be Classes 2A or 2B per ANSI B1.1 when connecting to cast-iron valves having body bolt holes.

F. Bolts for AWWA C207 Classes E and F flanges and ANSI B16.5 and B16.47 Class 300 flanges located indoors, and in vaults and structures shall be chrome molybdenum conforming to ASTM A 193, Grade B7, with nuts conforming to ASTM A 194, Grade 2H.

G. Bolts and nuts for buried or submerged Class 300 flanges and Class 300 flanges shall be Type 304 stainless steel conforming to ASTM A 193, Grade 8, Class 2, for bolts and ASTM A 194, Grade 8 for nuts.

H. Bolts used in flange insulation kits shall conform to ASTM A 193 (Grade B8). Nuts shall conform to ASTM A 194 (Grade 8).

I. Provide washers for each nut. Washers shall be of the same material as the nuts.

2.4 LUBRICANT FOR STAINLESS STEEL BOLTS AND NUTS

Lubricant shall be chloride free and shall be TRX-Synlube by Ramco, Anti-Seize by Ramco, Husk-It Husky Lube O'Seal, or equal..

PART 3 - EXECUTION

3.1 FABRICATION, ASSEMBLY, AND ERECTION

A. Beveled ends for butt-welding shall conform to ANSI B16.25. Remove slag by chipping or grinding. Surfaces shall be clean of paint, oil, rust, scale, slag, and other material detrimental to welding. When welding the reverse side, chip out slag before welding.

B. Fabrication shall comply with ANSI B31.3, Chapter V. Welding procedure and performance qualifications shall be in accordance with Specification Section IX, Articles II and III, respectively, of the ASME Boiler and Pressure Vessel Code.

C. The minimum number of passes for welded joints shall be as follows:

Steel Cylinder Thickness (inch)	**Minimum Number of Passes for Welds**
Less than 0.1875	1
0.1875 through 0.25	2
Greater than 0.25	3

Welds shall be full penetration.

D. Use the shielded metal arc welding (SMAW) submerged arc welding (SAW), flux-cored arc welding (FCAW), or gas-metal arc welding (GMAW) process for shop welding. Use the SMAW process for field welding.

E. Welding preparation shall comply with ANSI B31.3, paragraph 328.4. Limitations on imperfections in welds shall conform to the requirements in ANSI B31.3, Table 341.3.2, and paragraph 341.4 for visual examination.

F. Identify welds in accordance with ANSI B31.3, paragraph 328.5.

G. Clean each layer of deposited weld metal prior to depositing the next layer of weld metal, including the final pass, by a power-driven wire brush.

H. Welding electrodes shall comply with AWS A5.1.

3.2 SHOP TESTING OF FABRICATED OR WELDED COMPONENTS

A. After completion of fabrication and welding in the shop and prior to the application of any lining or coating, test each component according to the following requirements.

B. Test Method Requirements - Shop:

1. Test each section of steel pipe with the joint rings attached in the shop by the hydrostatic test method.

2. Test each section of fabricated bend and each fabricated reducer that is fabricated from steel pipe previously tested. Test the mitered joints by both the liquid penetrant method and the radiographic method. Alternatively, the fitting may be tested using the hydrostatic test method.

3. Assemble and retest flanged insulating joints by the hydrostatic test method. Test for electrical conductivity across joint.

4. Perform tests of production welds in accordance with AWWA C200 for each heat of steel used. A guided-bend test specimen shall be considered as having

passed only if no crack or other open defect exceeding 1/8 inch measured in any direction is present in the weld metal or heat affected zone of the base material after the bending. A tension test specimen shall be considered as having passed only if failure occurs in the base metal at a stress in excess of the minimum specified tensile strength. Perform at least one set of welding tests as described in AWWA C200, Specification Section 4.11.5 for each 1,000 lineal feet of spiral seam weld in addition to tests specified in Specification Section 4.11.6 of the same standard.

5. Inspect welds in the expanded portion of the pipe bell in accordance with the magnetic particle test.

6. Test backgouge and completed weld of manual process groove welds by the liquid penetrant method. Test completed fillet welds by the liquid penetrant method.

7. Perform 100% ultrasonic testing or liquid penetrant testing on manual process circumferential welds and welds at collars and risers.

8. Perform radiographic testing on 20% of the circumferential welds of fabricated bends and reducers, including junctions between circumferential and longitudinal welds.

9. Test the longitudinal welds of the bell and spigot of each section of steel pipe or fabricated steel cylinder that is to be field welded by the magnetic particle test method.

3.3 HYDROSTATIC, RADIOGRAPHIC, ULTRASONIC, SOAP AND COMPRESSED AIR, LIQUID PENETRANT, AND MAGNETIC PARTICLE TEST METHODS

A. Shop Hydrostatic Test:

1. Vent air from the pipe before the test pressure is applied. Hold the test pressure on each section for a sufficient length of time to permit inspection of all joints.

2. The hydrostatic test pressure for fabricated bends and pipes with outlets shall be the field hydrostatic test pressure or a minimum of 150 psi.

3. When subjected to the above hydrostatic test pressure, the pipe shall show no leaks, distortion, or other defects. Repair any leaks or other defects which develop during the hydrostatic test by chipping out and rewelding, after which the repaired section shall again be tested until it shows no leaks or other defects.

4. Test Bulkheads: Furnish and attach dished heads and blind flanges for making the hydrostatic tests, and after completion of the tests, remove the heads and properly restore the ends of the sections.

B. Radiographic Test: Make the radiographs in accordance with the requirements of the ASME Boiler and Pressure Vessel Code, Specification Section VIII, Pressure Vessels.

Repair defects in the welds disclosed by the radiographs. Submit all radiographs and the notation of areas for repair to the Owner's Representative for review.

C. Ultrasonic Test: Make the ultrasonic tests in accordance with the requirements of the ASME Boiler and Pressure Vessel Code, Specification Section VIII, Pressure Vessels. Repair defects in the welds disclosed by ultrasonic testing. Prepare a report of the ultrasonic testing and submit to the Owner's Representative for review.

D. Liquid Penetrant Test: Conform to the requirements specified in ASTM E 165, under Method B, and "Leak Testing." The materials used shall be either water washable or nonflammable. Products: "Spotcheck" by the Magnaflux Corporation or "Met-L-Check Flaw-Findr" by the Met-L-Check Company. Chip out all defects, reweld, and retest the section affected until it shows no leaks or other defects.

E. Magnetic Particle Test: Magnetic particle test shall conform to the requirements specified in ASTM E 709, using the dry powder technique. Chip out all defects, reweld, and retest the section affected until it shows no leaks or other defects.

3.4 PRODUCT MARKING

Plainly mark each length of straight pipe and each special and fitting at the bell end to identify the design pressure or head, the steel wall thickness, the date of manufacture, and the proper location of the pipe item by reference to the layout schedule. For beveled pipe, show the degree of bevel and the point on the circumference to be laid uppermost.

3.5 INSTALLING FLANGED PIPING

A. Set pipe with the flange bolt holes straddling the pipe horizontal and vertical centerline. Install pipe without springing, forcing, or stressing the pipe or any adjacent connecting valves or equipment. Before bolting up, align flange faces to the design plane within 1/16 inch per foot measured across any diameter. Align flange boltholes within 1/8-inch maximum offset.

B. Clean flanges by wire brushing before installing flanged fittings. Clean flange bolts and nuts by wire brushing, lubricate carbon steel bolts with oil and graphite, and tighten nuts uniformly and progressively.

C. Bolt lengths shall extend completely through their nuts by at least one complete thread for complete engagement. Any which fail to do so shall be considered unacceptable.

D. Do not use more than one gasket between contact faces in assembling a flanged joint.

E. If flanges leak under pressure testing, loosen or remove the nuts and bolts, reset or replace the gasket, reinstall or retighten the bolts and nuts, and retest the joints. Joints shall be watertight.

F. Install heat shrinkable sleeves, cold applied wax tape or threaded nut and bolt thread protection caps after completing the bolt, nut, and gasket installation as set forth herein. Install on buried and submerged piping.

3.6 INSTALLATION OF STAINLESS STEEL BOLTS AND NUTS

Prior to assembly, coat threaded portions of stainless steel bolts and nuts with lubricant as specified in Article 2.04 herein.

3.7 PAINTING AND COATING

A. Coat pipe located above ground or in vaults and structures in accordance with Specification Section 099000: PAINTING AND COATING, System 10. Prime coat shall be shop applied.

B. Pipe that is to be encased in concrete shall have no coating, unless shown otherwise in the drawings.

C. Coat the ends of plain-end buried pipe where flexible pipe couplings are to be installed per Specification Section 099000: PAINTING AND COATING, System 7. Apply coating in shop.

D. Coat the interior metal surfaces of blind flanges per Specification Section 099000: PAINTING AND COATING, System 7.

3.8 COATING BURIED AND SUBMERGED BOLTS, NUTS, AND TIE RODS

Coat buried bolts, nuts, and tie rods per Specification Section 099000: PAINTING AND COATING, System 7 or coat with cold applied wax tape per Specification Section 099550: COLD APPLIED WAX TAPE COATING.

3.9 FIELD THICKNESS MEASUREMENT AND REPAIR OF PAINT COATINGS FOR STEEL PIPE

A. Field repair shop applied prime coats per Specification Section 099000: PAINTING AND COATING.

B. Test linings and coatings per ASTM G 62, Method B, with a holiday detector set at 125 volts per mil coating thickness. Repair holidays and pinholes by applying the prime, intermediate, and finish coatings to each holiday or pinhole and retest.

C. Measure the lining and coating thickness on each pipe section using a calibrated coating thickness gauge. Make five separate spot measurements (average of three readings) spaced evenly over every 15 linear feet (or fraction thereof) to be measured. Make three gauge readings for each spot measurement of either the substrate or the paint. Move the probe a distance of 1 to 3 inches for each new gauge reading. Discard any unusually high or low gauge reading that cannot be repeated consistently. Take the average (mean) of the three gauge readings as the spot measurement. The

average of five spot measurements for each area shall not be less than the specified thickness. No single spot measurement in any area shall be less than 80%, nor more than 120%, of the specified thickness. One of three readings which are averaged to produce each spot measurement may underrun by a greater amount but in no case less than 75%. If a section of the pipe, item or piece of equipment does not meet these criteria for maximum thickness, remove the entire lining or coating and recoat the entire item or piece of equipment. If this does not meet minimum thickness requirements, clean and topcoat the surface with the specified finish coatings to obtain the specified coverage. Sandblast or power-sand visible areas of chipped, peeled, or abraded coating, feathering the edges. Then coat in accordance with the specifications. Work shall be free of runs, bridges, shiners, laps, or other imperfections.

D. Thickness determination shall meet the following requirements:

1. No individual reading shall be below 75% of specified thickness.

2. Individual spot readings (consisting of three point measurements within 3 inches of each other) shall have an average not less than 80% of specified thickness.

3. The average of all spot readings shall be equal to or greater than nominal thickness specified.

E. Thickness determinations shall be conducted using a Type 1 magnetic thickness gauge as described in SSPC PA2 specification.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT AND PAYMENT

Payment for the work in this section shall not be paid for separately, but shall be included as part of the lump-sum bid amount for each concrete structure or vault, per associated bid items, as stated in the bid proposal.

END OF SECTION 331500

SECTION 331613 FIRE PROTECTION STORAGE TANK

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.2 SUMMARY

A. This Section includes the provision of a welded construction for reservoirs for storage of domestic and fire-suppression water.

1.3 DEFINITIONS

A. Reservoir: Flat-bottomed, cylindrical, surface water-storage tank with shell height equal to or less than two times its diameter.

B. CR: Chlorosulfonated polyethylene synthetic rubber.

C. NR: Natural rubber.

D. PVC: Polyvinyl chloride plastic.

1.4 PERFORMANCE REQUIREMENTS

A. Structural Performance: Surface water-storage tank, including structural reinforcement and foundation, shall be capable of withstanding the effects of dead and live gravity loads and winds of 100 mph.

B. Seismic Performance: Surface water-storage tank, including structural reinforcement and foundation, shall be capable of withstanding the effects of earthquake motions determined according to authorities having jurisdiction.

C. Thermal Movements: Surface water-storage tank, including structural reinforcement and foundation, shall allow for thermal movements resulting from the following maximum change (range) in ambient and surface temperatures by preventing buckling, opening of joints, overstressing of components, failure of connections, and other detrimental effects. Base engineering calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.

1. Temperature Change (Range): 120 deg F, ambient; 180 deg F, material surfaces.

1.5 SUBMITTALS

A. Product Data: Include rated capacities, accessories, appurtenances, and furnished specialties for each surface water-storage tank indicated.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details for each surface water-storage tank, including the following:

1. Tank, roof, and shell openings.
2. Safety railings and ladders.
3. Plans, elevations, sections, details, and attachments to other work.
4. Structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
5. Power, signal, and control wiring.
6. Tank Heater.
7. Tank Insulation

C. Welding certificates.

D. Qualification Data: For fabricator. E. Bacteriological test results.

F. Field quality-control test reports.

G. Operation and Maintenance Data: For the following to include in emergency, operation, and maintenance manuals:

1. Obstruction lighting.
2. Lightning protection.
3. Cathodic protection.
4. Tank heaters.
5. Tank Insulation

1.6 QUALITY ASSURANCE

A. Fabricator Qualifications: Employ a qualified structural engineer to prepare calculations, Shop Drawings, and other structural data for fabrication and erection of surface water-storage tanks.

1. Engineering Responsibility: Preparation of data for surface water-storage tanks, accessories, specified appurtenances, and concrete supports and foundations, including Shop Drawings, based on testing and engineering analysis of manufacturer's standard units in assemblies similar to those indicated for this Project.

B. Welding: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code--Steel."

2. AWS D1.3, "Structural Welding Code--Sheet Steel."

3. AWS D1.4, "Structural Welding Code--Reinforcing Steel."

C. Pipe Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

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 for intended use.

E. Comply with AWWA D100, "Welded Steel Tanks for Water Storage," and with AWWA M42, "Steel Water-Storage Tanks," for welded-steel, surface water-storage tanks.

F. Comply with AWWA D103, "Factory-Coated Bolted Steel Tanks for Water Storage," and with AWWA M42, "Steel Water-Storage Tanks," for bolted-steel, surface water-storage tanks.

G. Comply with NFPA 22, "Water Tanks for Private Fire Protection," for surface water-storage tanks for fire-suppression water supply.

PART 2 - PRODUCTS

2.1 WELDED-STEEL RESERVOIRS

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:

1. Advance Tank and Construction Co.
2. Brown Tank & Steel.
3. Caldwell Tanks, Inc.
4. Chicago Bridge & Iron Company N.V.
5. Fisher Tank Company.
6. Maguire Iron, Inc.
7. Pittsburg Tank & Tower Co., Inc.
8. Superior Tank Co., Inc.
9. D+R Tanks.

B. Description: Welded-steel plates, bolts, rods, and reinforcing steel; designed and fabricated according to AWWA D100, AWWA M42, and NFPA 22.

1. Capacity: 300,000 gallons (approximately 40’ diameter by 32’ height).
2. Max Fill Rate and Withdrawal Rate: 1,132 gpm and 2,500 gpm
3. Pipe Connection: As Shown on Plans.

4. Overflow Piping: ASTM A 53/A 53M, Grade B, Schedule 40, welded-steel pipe with ASTM A 234/A 234M, Grade WPB, Schedule 40, carbon-steel butt-weld fittings.
5. Roof Hatch: Steel, hinged cover, 30 by 30 inches minimum with 4-inch neck and 2-inch downward overlap with hasp and lock, located over interior ladder and adjacent to exterior ladder.
6. Shell Sidewall Manholes: Two, steel, circular, 30 inches in diameter minimum.
7. Painter's Accessories: Include lugs, couplings, or rail inside and outside tank for painting.
8. Tank Vent: Steel pipe with stainless-steel screen, constructed to prevent entrance of rain, insects, birds, and animals. Include pressure-vacuum screened vent or separate pressure-vacuum relief mechanism to maintain clear screen.
9. Foundation: Reinforced concrete ringwall.

2.2 PAINT MATERIALS

A. Paint and Primer: Comply with AWWA D102 and as specified in 09 9600 Water Tank Coatings.

2.3 SHOP PAINTING

A. Factory coating according to AWWA D103.

B. Tank Shell Interior Finish Coat: Comply with NSF 61, suitable for domestic water.

C. Tank Shell Exterior Finish Coat: Factory coating according to AWWA D103.

2.4 SURFACE WATER-STORAGE TANK APPURTENANCES

A. Water-Level Controls: Automatic controls for maintaining water level in tank, with valves, piping, and audible and visual alarms to indicate the following:
   1. High- and low-water levels.
   2. Tank overflowing or tank not filling.

B. Obstruction Lighting: Comply with requirements of authorities having jurisdiction.

C. Lightning Protection: Comply with tank manufacturer’s recommendations.

D. Cathodic Protection: Comply with tank manufacturer’s recommendations and with AWWA D104.

E. Tank Heater: Comply with NFPA 22 and with capacity to maintain 42-degree F water temperature inside surface water-storage tank.
   1. Tank Heater shall be 480 Volt, 3 phase

PART 3 - EXECUTION

3.1 STEEL, SURFACE WATER-STORAGE TANK INSTALLATION

A. Erect tank shell, accessories, and appurtenances according to AWWA D100 and AWWA M42.

B. Welded-Steel Water Storage Tanks: Fabricate steel plate sections in the shop. Erect tank shell by welding plate sections in the field.

C. Set top of reinforced-concrete foundation at least 6 inches above finish grade.

D. Install roof hatch near exterior ladder.

E. Install tank vent at center of roof.

F. Install two manholes in tank wall near grade.

G. Install tank heater at location shown on plans.

3.2 CONNECTIONS

A. Piping installation requirements are specified in Division 33 Specifications. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect tanks to water-distribution piping.

C. Connect drains to storm-drainage piping.

D. Ground equipment according to Division 16 Section "Grounding and Bonding."

E. Connect wiring according to Division 16 Section "Conductors and Cables."

3.3 SURFACE PREPARATION OF STEEL TANKS

A. Surface preparation as specified in 09 9600 Coatings.

B. Field Cleaning: After erecting tank shell, remove burrs, dirt, and construction debris and repair damaged finishes. Remove weld splatter, sharp edges on weld seams, and scabs and slivers by grinding. Remove weld flux, slag, fins, and laminations.

C. Field Surface Preparation: After field cleaning, prepare steel surfaces where shop prime coat has been damaged, according to Specifications listed above for shop cleaning, and remove dust or residue from cleaned surfaces.

D. If surface develops rust before prime coat is applied, repeat field surface preparation.

3.4 FIELD PAINTING

A. Surface preparation is specified in Specification 09 9600 Coatings.

B. Apply paint according to AWWA D102.

C. Prime-Coat Touchup: Apply primer to cleaned areas and where shop finish has been damaged during shipping, handling, and erection. Apply prime coat for tank interior or exterior to the dry film thickness as specified in Division 09 9600 Coatings.

D. Interior Intermediate and Finish Coats: Apply intermediate and finish coats for tank interior or exterior to the dry film thickness as specified in Division 09 9600 Coatings.

E. Exterior Ladders: Paint as indicated for tank shell exterior.

F. Do not paint if ambient temperature is less than 50 degrees F or is expected to drop below 40 degrees F in the next 18 hours. Do not paint if temperature of steel surface is higher than 125 degrees F. Do not apply paint if surfaces are wet or damp, if precipitation is expected, or if relative humidity will exceed 85 percent. Do not spray paint when wind velocity exceeds 15 mph. Maintain at least a 24-hour waiting period between coats. Provide adequate ventilation in tank during painting to maintain clear atmosphere and provide explosion-proof flood lighting and spot lighting.

G. Complete daily painting to allow time for paint to dry before condensation is expected.

H. Application of coating system shall conform to the Paint Data Sheet and Paint Manufacturer’s recommendations and requirements.

3.5 SURFACE WATER-STORAGE TANK APPURTENANCE INSTALLATION

A. Install and adjust water-level control valves, piping, and alarms.

B. Install obstruction lighting according to authorities having jurisdiction.

C. Install lightning protection according to tank manufacturer’s design.

D. Install cathodic protection according to tank manufacturer’s design and AWWA D104.

E. Install tank heaters according to NFPA 22.

3.6 FIELD QUALITY CONTROL

A. Testing: A qualified testing agency to perform the following field quality- control testing shall be provided by the Contractor:

1. Welded-Steel Water Storage Tank Weld Test: Use radiographic method according to AWWA D100. Repair failures and retest.
2. Welded-Steel Water Storage Tank Leak Test: Comply with AWWA D100 and NFPA 22.

   Fill tanks with potable water and test for leaks after installation. Repair leaks and retest until no leaks exist.

   a. Water will be furnished by Owner.
3. Bolted-Steel Water Storage Tank Leak Test: Comply with AWWA D103 and NFPA 22.

   Fill tanks with potable water and test for leaks after installation. Repair leaks and retest until no leaks exist.

   a. Water will be furnished by Owner.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Remove and replace malfunctioning units and retest as specified above.

3.7 CLEANING

A. Clean interior and exterior of surface water-storage tanks.

B. Disinfect surface water-storage tanks according to AWWA C652 and requirements of authorities having jurisdiction.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain the following. Refer to Division 1 Section "Demonstration and Training."

1. Obstruction lighting.
2. Water-level controls.
3. Tank Heater.

PART 4 – MEASUREMENT AND PAYMENT

A. Work covered in this section of the specifications, and associated costs therewith, shall be included in the lump sum bid item to which the work applies. Payment shall include coating testing and inspection and eleven-month anniversary inspection.

END OF SECTION 331613

SECTION 333000 SANITARY SEWER UTILITIES

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. All work and materials in this Section shall be performed in accordance with the Contract Drawings and the New Mexico Public Works Association Standard 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)

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. Pipes and appurtenances for potable water.

1.2 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 and fittings
2. Access Manway frames and grates

PART 2 – PRODUCTS

2.1 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.

2.2 PIPE BEDDING AND TRENCH BACKFILL MATERIALS

A. Trenches shall be excavated in accordance with the requirements of the New Mexico Public Works Association Standard Specifications 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. Bedding Material is specified in Section 31 00 00 of these specifications.

C. 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 6” or greater, and deleterious materials, and shall be subject to the approval of the Engineer.

PART 3 – EXECUTION

3.1 TRENCH EXCAVATION

A. Trenching operations shall be performed in accordance with Section 31 00 00 of these specifications.

3.2 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. Frames shall be embedded in mortar and bear uniformly on the structure such that there is no movement or "rocking".

3.3 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.

3.4 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.

3.5 CLEANING INSPECTION AND TESTING

A. The Contractor shall provide necessary materials, equipment, and labor to perform the tests as described herein.

B. The sanitary sewer lateral shall be tested for exfiltration.

C. 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:

PIPE DIAMETER	MINIMUM ALLOWABLE TIME INTERVAL (inches) (minutes: Seconds)
6	2:15
8	4:00
10	4:45
12	5:40
15	7:05
18	8:30

D. The Contractor shall maintain the pipe and structures in clean working condition until final acceptance by the Owner.

END OF SECTION 333000

SECTION 334000 - STORM DRAIN UTILITIES

PART 1 - GENERAL

1.1 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.

1.2 RELATED SECTIONS:

A. 310000 Earthwork

1.3 QUALITY ASSURANCE:

A. All work and materials shall be in full accordance with the New Mexico Public Works Association Standard Specifications, Latest Edition, including all updates, and all applicable laws, codes, and regulations.

PART 2 – PRODUCTS

2.1 STORM DRAINAGE SYSTEM:

A. 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.

B. High Density Polyethylene Pipe (HDPE):

1. Acceptable manufacturer: Hancor or ADS. Use of HDPE requires a pre-construction meeting with manufacturer’s representative to ensure proper installation practices are understood and used by contractor.
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

3.1 EXCAVATION AND BACKFILL:

A. Trenches shall be excavated in accordance with the requirements of the New Mexico Public Works Association 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 New Mexico Public Works Association Standard Specifications.

C. When HDPE is used backfill shall conform with the requirements of the Manufacturer's Specifications.

3.2 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.

3.3 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.

3.4 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 Public Works Association 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 334000

SECTION 335219 FIRE PUMP SYSTEM / PRE- PACKAGED

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.2 DESCRIPTION OF WORK

A. Contractor shall furnish all labor, materials, equipment, and incidentals required to provide and diesel fire pump system with domestic water capability. The skid mounted equipment will be pre-wired, pre-plumed and as a package system with full controls as specified herein.

1.3 SUBMITTALS

A. Product Data: The submittal data for the pumping system shall include, but is not limited to: pump curves, system drawings, and complete description of control panel, with wiring diagrams, sequence data, instrumentation, alarms.

B. Shop Drawings: Show location and details of operational hardware and accessories. Indicate materials, dimensions, sizes, weights, and finishes of components. Include plans, elevations, sections and other required installations and operational clearances, and details of anchorage and attachment and bracing.

C. Wiring Diagrams: Power and control wiring. Differentiate between manufacturer-installed and field installed wiring and between components provided by manufacturer and those provided by others.

D. Product Certificates: Signed by manufacturers certifying that products furnished comply with requirements.

E. 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, name and address of architects and owners, and other information specified.

F. Pre-Approval Requirements: Pre-submittal data as listed from paragraphs 1.3.A through 1.3.E, to include certified AutoCAD 2000, Mechanical desktop, 3-D drawing, with electrical wiring diagrams for the entire prepackaged unit. Data to be submitted no later than 15 days prior to bid date for engineer consideration. No exceptions.

G. Field Test Reports: Provide an on-site fire pump test start up report for compliance with performance requirements.

PART 2 – PRODUCTS

2.1 OPERATING CONDITIONS & SYSTEM REQUIREMENTS

A. Contactor shall furnish and install a Canariis series engineered package pump system with all labor, materials, equipment, and incidentals required to provide. The provider must be an authorized fire pump distributor in the State of New Mexico with full factory authorized fire pump start up, maintenance and training capability.

B. The diesel fire system shall be capable of 2,500 gpm at 125 psi. Suction pressure is from a tank and not expected to exceed 15 psi.

2.2 FIRE PUMPING SYSTEM CONSTRUCTION

A. The contractor shall provide and install a packaged fire pump systems designed in accordance with NFPA 20. The system shall be rated for a flow of 2,500 gpm at 125psi. The system shall have all necessary components such as the customer only need to run piping to and from the house system and connect to incoming power, alarm, and relays.

B. The fire pump shall be an Aurora horizontal split case, bronze fitted, double suction centrifugal pump. The system will have an Aurora pump to match other system pumps. The pump shall be rated for 2,500 gpm at 125 psi. The pump shall be listed by the Underwriters' Laboratory and or be approved by Factory Mutual. The pump shall deliver no less than 65% of the rated pressure at 150% of the rated flow. The shut off pressure shall not exceed 140% of rated pressure. The pump shall operate at a maximum synchronous speed of 1760 R.P.M. The Fire Pump shall be: AURORA MODEL 481 Horizontal Base Mounted split case pump, size 8-481-17B4C, bronze fitted, SINGLE STAGE, double suction centrifugal pump. **Inline pumps and end suction pumps will not be accepted.**

C. Casings shall be of cast iron having a minimum tensile strength of 35,000 P.S.I. Bearing housing supports, and suction and discharge flanges shall be integrally cast with the lower half of the casing. **Bolt on exterior bearings will not be approved.** Removal of the upper half of the casing must allow the rotating element to be removed without disconnecting the suction and discharge flanges. Impellers shall be of the enclosed type and shall be of vacuum cast bronze. Impellers shall be dynamically balanced, keyed to the shaft, and held in place with threaded shaft sleeves. **Pumps without shaft sleeves will not be accepted.** The pump shaft shall be made of SAE 1045 Steel or equal, accurately machined to give a true running rotating element. Shaft shall be protected by bronze sleeves which are key locked and threaded so that the sleeves tighten with the rotation of the shaft. An O-ring shall seal between the impeller hub and the shaft sleeve to protect the pump shaft. Pump shall be equipped with renewable bronze casing rings so designed that hydraulic pressure will seat them against a shoulder in the pump case around the full periphery of the wearing ring. **Pumps without case wearing ring will not be accepted.** The wearing rings will

be locked by dowelling to prevent rotation. The rotating element uses heavy duty grease lubricated ball bearings and shall be equipped with water slingers. Bearing housings shall be so designed to flush lubricant through the bearing.

MATERIALS OF CONSTRUCTION:

- Casing.....Cast Iron (ASTM A48)
- Impeller.....Bronze (ASTM B62)
- Shaft.....Carbon Steel (AISI C1045)
- Shaft Sleeve.....Bronze (ASTM B62)
- Case Wear Ring.....Bronze (ASTM B62)

D. The pump will have lantern rings connected to the pressure side of the pump by a cored passage in the parting flange of the pump. Stuffing boxes shall be equipped with split bronze packing glands designed for easy removal for packing inspection and maintenance.

E. Pump and driver shall be mounted on a common base plate of steel. Pump and motor shall be checked for alignment after the pump base has been installed and grouted in place.

F. The diesel engine shall be a JW6H Series Clarke, rated at 291 hp, meeting USA EPA Tier 3 Emissions Certified Off-Road and NSPS Stationary. RPM is not to exceed 1760 rpm.

G. The controller shall meet the requirements of the most recent edition of NFPA20 and shall be listed by Underwriters Laboratories, Inc. and approved by Factory Mutual Research Corporation. The controller shall be (12 or 24 - select one) volts, negative ground and shall be field configured to be compatible with all listed diesel type fire pump engines. Controllers limited to specific models will not be acceptable.

1. The enclosure shall be NEMA Type 2, lockable with breakable, transparent Mode Switch cover, suitable for floor or wall mounting. The enclosure shall be painted with a UL recognized corrosion resistant red, heat set, powder coat paint.
2. STANDARD, LISTING AND APPROVAL:
   - NFPA 20
   - UL (UL218)
   - FM Global (Class 1321/1323)
   - City of New York for fire pump service
3. MANUFACTURER AND MODEL
   - Tornatech model GPD
4. SEISMIC CERTIFICATION
   - Test Criteria
     - ICC-ES AC156
   - Building Code
     - IBC 2015
     - CBC 2016

- OSHPD Special Seismic Certification Preapproval – OSP
- Seismic Parameters
  - ASCE 7-10 Chapter 13

5. ENCLOSURE
   - NEMA 2
   - Bottom conduit entry gland plate
6. OPERATIONAL COMPONENTS
   - Hand-OFF-Auto selector switch installed behind lockable breakable cover.
7. TOUCH SCREEN OPERATOR INTERFACE
   - 7.0” LCD color touch screen (HMI technology) operator interface powered by an embedded microcomputer with software PLC logic
   - Keypad type pushbuttons:
     a. Crank from Battery #1
     b. Crank from Battery #2
     c. Stop
     d. Run test
   - On-Screen Menu:
     a. Home
     b. Alarms
     c. Configuration
     d. History
     e. Service
     f. Manuals
     g. Language
   - Shall graphically display:
     a. AC power present
     b. Charger #1 and #2 charging mode
     c. Battery #1 and #2 voltage and amperage
     d. System pressure
     e. Cut-out and cut-in pressure settings
     f. Starter #1 and #2 rest or cranking
     g. Engine stopped / running
     h. Type of starting cause
     i. Fuel solenoid valve energized / not energized
     j. Timers counting
     k. Hand-OFF-Auto selector switch position
     l. Actuation mode
     m. Type of controller
     n. Method of shutdown
     o. Time and date
     p. Pump room temperature (ºF or ºC)

q. Digital pressure gauge

H. The Fire Pump NFPA 20 alarms, and all tamper switches shall be looped together into one alarm circuit. This pump house alarm will be wired to a house mounted alarm system that will notify the owner of alarm status on a continuous basis. And will page the owner on system trouble or system activation. This system will come with a 1-year monitoring fee paid in advance by the manufacturer. System display will be a red light above the door of the pump house. Any fire pump alarm, pump trouble or tamper switch movement will energize the light and page to owner with an internet display of system trouble.

I. Accessories shall include: automatic air release, suction and discharge gauges on the fire pump, Isolating gate valve at suction of the fire pump, discharge check valve for the fire pump.

J. Options for this system shall include: Test heater (shipped loose for onsite mounting), flow metered loop line complete with isolating and check valves, Fire pump house complete with sprinkler system.

2.3 HOUSING SYSTEM CONSTRUCTION

A. All of the above equipment, (except the test header and hose valves) shall be mounted on an open I-Beam / C Channel frame. All pipes, piping components, and the pressure sensing lines shall be firmly anchored to the steel base by means of structural steel supports. All electrical wiring between domestic water system, controllers, and motors shall be completed and tested at the factory. All controls, pump sequencing devices, alarms and instrumentation shall be tested and calibrated for proper operation during factory testing. The entire package shall be hydrostatically tested at the factory prior to shipment. Additionally, all equipment is to be tested in accordance with the requirements of NFPA, UL and FM.

B. The building electrical system shall have (1) spare set of main power lugs to accommodate inclusion of addition equipment such as a well pump, (2) spare 120 volt, 20 amp breakers labeled as spares, (2) GFI convenience receptacles. All tamper and flow switches shall be wired to a common dry contact for suitable connection to building alarm trouble system.

C. Each building shall be supplied complete with all necessary component parts to form a complete building system and all parts shall be new and free from all defects or imperfections. The building width and length shall be measured from the outside of the building wall panels and the height of the building shall be the distance measured from the bottom surface of the base channel to the exterior juncture of the roof and sidewall panels.

D. All buildings shall be designed in accordance with the applicable section to the latest edition of the AISC “Specification for structural steel building” the AISI “specification for the design of Cold Formed Steel Structural Members”.

E. Each building shall be designed for the following loads:

1. The vertical load of the building shall not be less than 40 pounds per square foot applied on the horizontal projection of the roof.

2. The horizontal wind load of the building shall not be less than 110 MPH and shall be distributed and applied in accordance with the applicable edition of the Metal Building Manufacturer's Association (MBMA) publication titled "Low Rise Building System Manual".

3. The building and portion there of shall be designed to resist the effects of seismic ground motions that might expected in seismic zones.

F. Reduction loads due to tributary loaded areas shall not be permitted. All combining and distributing of auxiliary equipment loads imposed on the building system shall be done in accordance with the applicable section of the MBMA publication titled, "Low rise Building System manual".

G. The House must contain a New Mexico seal of construction sticker.

H. Option for the house must contain: at a minimum 20 gauge Hollow metal doors, Exhaust fan consisting of shutter, fan assembly, wall sleeve, and rear guard. Fan shall have a 115V, 1/6 hp direct totally enclosed motor for continuous duty with thermal overload protection built in. Rear guard shall conform to OSHA specifications. Solenoid operated louvers shall be O flanged self-framing design. The louver frame shall be nominal 14 gauge formed aluminum and the louver blades shall be minimal 12 extruded aluminum. Solenoid operator is designed for use with single panel wall louver, Unit opens wall louver when fan motor is activated, and spring returns louver when deactivated. Lighting to include normal inside lighting with emergency back up and exterior lighting by all doors.

2.4 WARRANTY AND START UP

A. The entire package provided system shall be warranted in writing against defects in materials or workmanship under normal use and service for a period of one year after date of original operation but not more than 18 months from date of shipment from the Company's factory when installed and used in accordance with good standard practice.

B. Startup shall consist of a full fire pump witnessed test with a written report back to the Engineer.

C. One maintenance visit on the 12-month anniversary after startup shall be performed at the manufacturer's cost with a written report of findings and maintenance performed.

END OF SECTION 335219