

**PROJECT
MANUAL**

NMERB New Office Building

Project Number: 21-0371.001

Volume 2 of 2

12/21/2022

Issued for Permit

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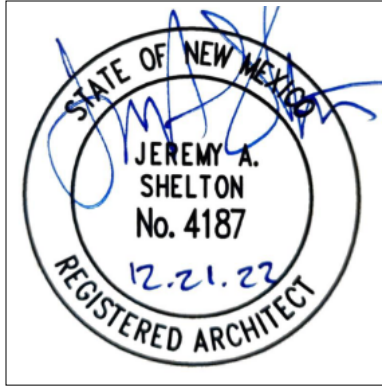
**Architecture
in Progress**

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DOCUMENT 00 0107 – SEALS PAGE

ARCHITECT

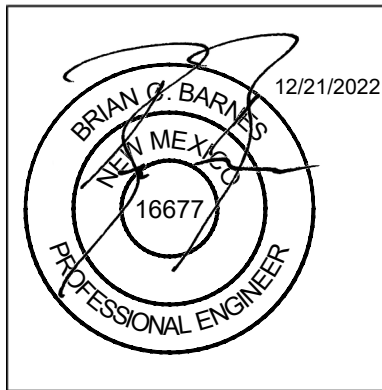
Responsible For Sections:



Division 01	All Sections
Division 03	Section 03 3511 – Concrete Floor Finishes
Division 04	Section 4 2000 – Unit Masonry
Division 05	Section 05 5000 - Metal Fabrications Section 05 5133 – Metal Ladders
Division 06	All Sections
Division 07	All Sections
Division 08	All Sections
Division 09	All Sections
Division 10	All Sections
Division 11	All Sections
Division 12	All Sections
Division 32	All Sections unless noted otherwise

STRUCTURAL

Responsible For Sections:



Division 03	All Sections unless noted otherwise
Division 05	Section 05 1200 – Structural Steel Framing Section 05 2100 – Steel Joist Framing Section 05 3100 – Steel Decking Section 05 4000 – Cold-Formed Metal Framing
Division 06	All Sections unless noted otherwise

LANDSCAPE

Responsible For Sections:

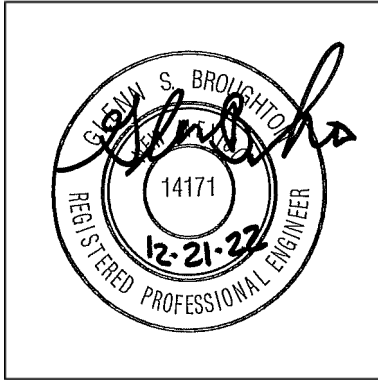


Division 32	Section 32 8423 – Irrigation System Section 32 9300 – Plants
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CIVIL

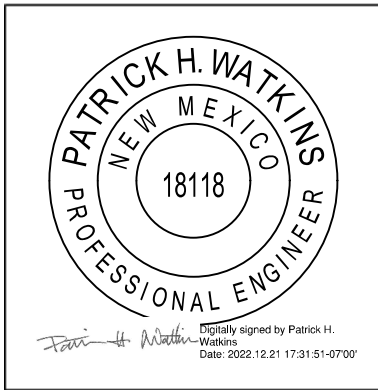
Responsible For Sections:



- Division 31 All sections unless noted otherwise
- Division 32 Section 32 1200 - Flexible Paving
Section 32 1300 - Concrete Pavement Curb Sidewalk
- Division 33 All sections unless noted otherwise

PLUMBING & MECHANICAL

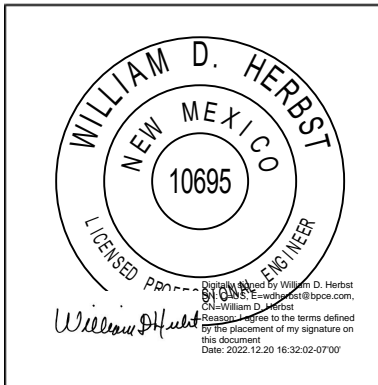
Responsible For Sections:



- Division 21 All Sections
- Division 22 All Sections
- Division 23 All Sections

ELECTRICAL

Responsible For Sections:



- Division 26 All Sections

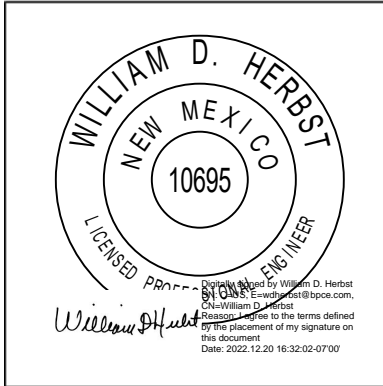
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TECHNOLOGY

Responsible For Sections:

Division 27 All Sections

Division 28 All Sections



END OF DOCUMENT

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END OF SECTION

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PART 1 GENERAL

1.1 SCOPE OF WORK

- A. See General Conditions and Supplemental General Conditions.
- B. The requirements listed under General Conditions and Supplemental General Conditions and the General Requirements are applicable to this section and all subsequent sections of Division 21 and form a part of the contract.
- C. Division 22 for Plumbing Systems.
- D. Division 23 for Heating, Ventilating and Air Conditioning (HVAC) Systems.
- E. Division 26 for Electrical Systems.
- F. Division 28 for Fire Alarm Systems.
- G. Division 31, for Trenching, Backfilling and Compaction requirements.
- H. Division 33 for requirements of site utility systems, including sanitary sewer, storm sewer, domestic water distribution system, fire main water distribution system, and natural gas service.
- I. All electrical work, regardless of voltage which is provided under Division 21 shall comply with the requirements of the National Electric Code (NEC) and Division 26.

1.2 FIRE SUPPRESSION DIVISION INDEX

Section 21 0500 Common Work Requirements for Fire Suppression
Section 21 0503 Trenching and Backfilling for Fire Suppression
Section 21 0504 Pipe and Pipe Fittings for Fire Suppression
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Section 21 0548 Vibration and Seismic Control for Fire Suppression
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 Santa Fe, and the National Fire Protection Association (NFPA Regulations), current adopted edition,

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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 conjunction 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.

PART 2 PRODUCTS

2.1 QUALITY OF MATERIALS

- A. All equipment and materials shall be new, and shall be the standard product of manufacturers regularly engaged in the production of fire suppression equipment and shall be the manufacturer's latest design. Specific equipment, shown in schedules on drawings and specified herein, is to set forth a standard of quality and operation.
- B. Hazardous or Environmentally Damaging Materials: Products shall not contain asbestos, mercury, PCBs, or other materials harmful to people or the environment.

2.2 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.

2.3 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.

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- B. The Contractor shall coordinate completely with all trades and Sub-Contractors as required to ensure that all necessary components of control work are included and fully understood. No additional cost shall accrue to the Owner as a result of lack of such coordination.
- C. The fire suppression piping system may be bonded to the electrical ground bus at the electrical service equipment, but shall not under any circumstances be used as the main grounding electrode for the electrical service.

2.4 PAINTING

- A. All finish painting of fire suppression systems and equipment will be under "Painting," unless equipment is hereinafter specified to be provided with factory applied finish coats.
- B. All equipment shall be provided with factory applied prime finish, unless otherwise specified.
- C. Touch-Up: If the factory finish on any equipment is damaged in shipment or during construction of the building, the equipment shall be refinished.

2.5 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.

2.6 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:

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- 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.

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- 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

2.7 IDENTIFICATION OF CONTROL SYSTEM DEVICES

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

2.8 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.

PART 3 EXECUTION

3.1 COOPERATION WITH OTHER TRADES

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

3.2 DESIGN AND DRAWINGS

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

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

- C. Should any doubt or question arise in respect to the true meaning of the drawings or specifications, the question shall be submitted in writing.
- D. Installation of all fire suppression equipment and piping systems shall be arranged to provide all clearances required for equipment operation, service, and maintenance, including minimum clearances required by applicable codes, manufacturer's installation instructions and as necessary for proper clearance in front of all electrical panels as defined by the National Electric Code (NEC). Piping systems shall not be routed through or above electrical equipment room or electrical equipment space designed within mechanical equipment rooms.
- E. The Contractor's attention is directed to the unique architectural design features and consideration associated with this facility which will require significantly greater levels of coordination and cooperation for the work furnished and installed under Division 21 with the associated architectural, structural, and electrical work than is normally necessary for a more typical facility.
- F. The installation of all concealed fire suppression systems shall be carefully arranged to fit within the available space without interference with adjacent mechanical, plumbing, structural and electrical systems. The Contractor shall make all necessary provisions for penetrations of piping, including sleeves and blockouts in structural systems. The exact location of all exposed fire suppression systems, including access doors; sprinkler piping exposed within finished areas; and other equipment and devices as applicable, shall be coordinated with the Architect, who shall have final authority for the acceptance of the work as it specifically relates to the architectural aesthetic design requirements for the facility. In no instance shall the building vapor barrier system be penetrated by the fire suppression system installation without written approval.

3.3 FIELD MEASUREMENTS

- A. The Contractor shall verify the dimensions and conditions governing his work at the building. No extra compensation shall be claimed or allowed on account of differences between actual dimensions, including dimensions of equipment, fixtures and materials furnished, and those indicated on the drawings. Contractor shall examine adjoining work, on which his work is dependent for perfect efficiency, and shall report any work which must be corrected. Coordination of all fire suppression work within the building will be the direct responsibility of

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the Contractor. Review of submittal data in accordance with paragraph "Submittals" shall in no manner relieve the Contractor of responsibility for the proper installation of the fire suppression work within the available space. Installation of equipment and systems within the building space shall be carefully coordinated by the Division 21 Contractor with all building trades. Each contractor shall so harmonize his work with that of the several other trades that it may be installed in the most direct and workmanlike manner without hindering or handicapping the other trades. Piping interferences shall be handled by giving precedence to pipe lines which require a stated grade for proper operation. Sewer lines shall take precedence over water lines in determination of elevations. In all cases, lines requiring a stated grade for their proper operation shall have precedence over electrical conduit and ductwork. Installation of fire suppression, plumbing and HVAC systems within the ceiling cavity shall be in the following order of priority: plumbing waste lines; roof drains; supply, return, outside air, makeup, and exhaust ductwork; fire sprinkler mains; fire sprinkler branch piping and sprinkler runouts; heating hot water and chilled water piping; domestic hot and cold water; control piping, wiring and conduit; miscellaneous special piping systems.

3.4 EQUIPMENT SUPPORT

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

3.5 SEISMIC SUPPORTS

- A. The Contractor shall be responsible for all anchors and connections for the mechanical work to the building structure to prevent damage of equipment and systems due to earthquakes. The complete fire protection systems shall be supported as required to resist stresses produced by lateral forces as required by NFPA No. 13. 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.

3.6 PROTECTION OF MATERIALS AND EQUIPMENT

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

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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.

3.7 TRENCHING AND BACKFILLING

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

3.8 MANUFACTURER'S INSTRUCTIONS

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

3.9 TESTS

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

3.10 OPERATION AND MAINTENANCE INSTRUCTIONS

- A. The Contractor shall furnish complete operating and maintenance instructions covering all units of fire suppression equipment herein specified together with parts lists. Equipment spare parts shall include all components requiring service, including motors, bearings, shafts, etc. Furnish 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.

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- 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.

3.11 CERTIFICATIONS

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

3.12 SITE VISITS AND OBSERVATION OF CONSTRUCTION

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

END OF SECTION

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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?

3. List differences between proposed substitutions and specified item.

Specified Item	Proposed Substitution
_____	_____
_____	_____
_____	_____

4. Does substitution affect Drawing dimensions? YES NO

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

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

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

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

9. Does proposed product contain asbestos in any form? YES NO
SUBMITTED BY: Firm: _____ Date: _____

Address: _____

Signature: _____ Telephone: _____

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

LICENSE AGREEMENT FOR CADD DATABASE OR BIM MODEL

PROJECT: _____

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

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

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

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

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

CONTRACTOR'S REPRESENTATIVE

Signature: _____ Company Name: _____

Name: _____ Address 1: _____

Title: _____ Address 2: _____

Date: _____

SECTION 21 0503 - TRENCHING AND BACKFILLING FOR FIRE SUPPRESSION

PART 1 GENERAL

1.1 REQUIREMENTS

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

1.2 SCOPE OF WORK

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

PART 2 PRODUCTS

Not Applicable

PART 3 EXECUTION

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

END OF SECTION

SECTION 21 0504 - PIPE AND PIPE FITTINGS FOR FIRE SUPPRESSION

PART 1 GENERAL

1.1 REQUIREMENTS

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

1.2 RELATED SECTIONS

- A. Section 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 staving 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

SECTION 21 0505 - PIPING SPECIALTIES FOR FIRE SUPPRESSION

PART 1 GENERAL

1.1 REQUIREMENTS

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

1.2 RELATED SECTIONS

- A. Section 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.

PART 2 PRODUCTS

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

PART 3 EXECUTION

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

END OF SECTION

SECTION 21 0523 - VALVES FOR FIRE SUPPRESSION

PART 1 GENERAL

1.1 REQUIREMENTS

- A. All Valves shall conform with current applicable provisions of the General Conditions, Supplemental General Conditions, and General Requirements.
- B. All Valves shall meet the current MSS Specifications covering Bronze & Iron Valves. MSS-SP-80, MSS-SP-70, MSS-SP71, MSS-SP-85 where applicable.
- C. Lead Ban: Valves shall be lead free. The term lead free is defined as valves which do not contain more than 8.0% lead.

1.2 RELATED SECTIONS

- A. Section 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.

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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

SECTION 21 0548 - VIBRATION AND SEISMIC CONTROLS FOR FIRE PROTECTION

PART 1 GENERAL

1.1 REQUIREMENTS

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

1.2 RELATED SECTIONS

- A. Section 21 0500, Common Works Requirements for Fire Suppression.
- B. Section 21 0504, Pipe and Pipe Fittings.
- C. Section 21 0900, Instrumentation and Control for Fire Suppression System.

1.3 SCOPE

- A. It shall be understood that the requirements for seismic restraints are in addition to other requirements as specified elsewhere for the support and attachment of equipment and mechanical services, and for the vibration isolation of same equipment. Nothing on the project drawings or specifications shall be interpreted as justification to waive the requirements for seismic restraint as specified herein, shown on the drawings and required by Code.
- B. The work under this section shall include furnishing all labor, materials, tools, appliances and equipment, and performing all operations necessary for the complete execution of the installation of seismic snubber restraint assemblies as shown, detailed and/or scheduled on the drawings and/or specified in this section of the specifications.
- C. The materials and systems specified in this section shall be provided by the Contractor from a single Seismic Snubber Restraint Materials Manufacturer to assure sole source responsibility for the performance of the seismic restraints used.
- D. The seismic snubber restraint materials manufacturer shall be responsible for detailed design for seismic supports, including calculation for size and attachment, signed and sealed by registered State of New Mexico Structural Engineer.

1.4 SUBMITTALS

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

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- 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 be 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.

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- C. All items of fire protection equipment required for life safety including the fire pump and fire protection systems shall be provided with seismic restraints securely anchored to the building capable of resisting horizontal forces of 100% of their weight and/or in accordance with IBC Requirements.
- D. All items of fire protection equipment, except as specified above, and all piping furnished and installed under Division 21 shall be provided with seismic restraints securely anchored to the building capable of resisting horizontal forces of 50% of their weight.
- E. Seismic restraint/snubber manufacturer shall be responsible for the structural design of attachment hardware as required to attach seismic restraints/snubbers to both the equipment and supporting structure on vibration isolated equipment, or to directly attach equipment to the building structure for non-isolated equipment.
- F. The Contractor shall furnish a complete set of approved shop drawings of all mechanical and electrical equipment which is to be restrained to the seismic restraint manufacturer, from which the selection and design of seismic restraint devices and/or attachment hardware will be completed. The shop drawings furnished shall include, at a minimum, basic equipment layout, length and width dimensions, installed operating weights of the equipment to be restrained and the distribution of weight at the restraint points.

PART 2 PRODUCTS

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

PART 3 EXECUTION

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

END OF SECTION

**SECTION 21 0549 FIRE SUPPRESSION AND ELECTRICAL INSTALLATION
COORDINATION**

PART 1 GENERAL

1.1 REQUIREMENTS

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

1.2 RELATED DIVISIONS AND SECTIONS

- A. Section 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.

PART 2 PRODUCTS

Not Applicable.

PART 3 EXECUTION

3.1 INSTALLATION

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

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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

**SECTION 21 1313 FIRE PROTECTION SYSTEM, AUTOMATIC WET-PIPE
SPRINKLE**

PART 1 GENERAL

1.1 REQUIREMENTS

- A. Conform with applicable provisions of the General Conditions, Supplement General Conditions and the General Requirements.
- B. Division 3 for concrete work.
- C. Division 26 for electrical work and building fire alarm system.

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.

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- 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 ft².

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.

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- 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

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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.

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- 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.

PART 2 PRODUCTS

2.1 GENERAL

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

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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."

2.2 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.

2.3 FITTINGS

- A. Changes of direction shall be accomplished by the use of fittings suitable for use in sprinkler systems as defined in Article 3-13 of NFPA 13. 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.

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- E. Face bushings and hexagonal bushings shall not be permitted.
- F. Threaded pipe and fittings shall be used in all exposed areas.

2.4 JOINTS

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

2.5 UNIONS AND FLANGES

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

2.6 HANGERS AND SUPPORTS

- A. See Section 21 0504, Pipe and Pipe Fittings, for general requirements associated with equipment piping systems hangers and supports. Seismic supports for fire protection system shall be provided in accordance with NFPA requirements.
- B. All fire protection piping shall be rigidly supported from the building structure by means of adjustable ring type hangers. Piping hangers shall be spaced as specified in NFPA 13, Chapter 2. Piping system shall be installed in an approved manner and shall not overload the structure. The Contractor shall provide additional hangers and steel support members as may be required to distribute the piping weight over several structural members where required or directed. Fire protection piping system shall be supported independent and shall not be attached or supported from hangers, trapezes, or supports provided for other piping systems or equipment.

2.7 VALVES

- A. See Section 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.

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- 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.

2.8 ALARM CHECK VALVES

- A. Furnish complete wet-pipe sprinkler system alarm check valve assembly with all accessories required for system operation, supervision and alarm. Valves shall be UL listed and FM approved, designed to automatically activate electrically and/or hydraulically operated alarms and shall be furnished in the required size and arrangement with either flanged or grooved connections.
- B. Furnish retard chamber, pressure gauges, valves, and trim including water motor gong and alarm switch with both normally open and normally closed electrical contacts.
- C. Alarm check valve assembly shall be as manufactured by Tyco Fire Products or equivalent.

2.9 PRESSURE GAUGES

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

2.10 TAMPER SWITCHES

- A. All valves which control water to automatic sprinkler heads shall be equipped with supervisory switches having one normally open contact and one normally closed contact. Valve supervisory

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

2.11 FLOW SWITCHES

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

2.12 SPRINKLER HEADS

- A. Sprinkler heads and accessories shall be UL listed or FM approved for the intended service, quick response automatic closed type, 165 deg F rated with 1/2" orifice, except as may be otherwise required for the specific application, and subject to NFPA 13 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.

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- 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.

2.13 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.

PART 3 EXECUTION

3.1 FIELD CONDITIONS

- A. Prior to installation the Contractor shall carefully inspect the installed work of all other trades and verify that all such work is complete to the point where the installation of the sprinkler system may properly commence.
- B. The Contractor shall verify that the entire sprinkler system may be installed in accordance with all referenced codes, regulations, standards, and the original approved design.

3.2 INSTALLATION

- A. General
 - 1. The complete fire protection system shall be installed in accordance with NFPA 13. The project drawings provide general information concerning the system arrangements,

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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

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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.

3.3 EQUIPMENT INSTALLATION

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

3.4 TEMPORARY FIRE PROTECTION

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

3.5 INSPECTION AND TESTING

- A. The complete fire protection systems and piping acceptance testing shall be performed by the Contractor and witnessed. Advance notice shall be given by the Contractor prior to any tests.
- B. Inspection Prior to Testing: The Contractor shall submit notification upon completion of the installation of all materials and equipment.

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- 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.

3.6 CERTIFICATION

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

3.7 MAINTENANCE AND OPERATING INSTRUCTIONS

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

END OF SECTION

SECTION 22 0500 COMMON WORK REQUIREMENTS FOR PLUMBING

PART 1 GENERAL

1.1 SCOPE OF WORK

- A. See General Conditions and Supplemental General Conditions.
- B. The requirements listed under General Conditions and Supplemental General Conditions and the General Requirements are applicable to this section and all subsequent Sections of Division 22 and form a part of the contract.
- C. Division 21 for Fire Suppression Systems.
- D. Division 23 for Heating, Ventilating & Air Conditioning (HVAC) Systems.
- E. Division 26 for Electrical Systems.
- F. Section 22 0503 for Trenching, Backfilling and Compaction requirements.
- G. 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 0548	Vibration and Seismic Controls 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 1400	Facility Roof and Area 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 the International Building Code, 2015 Edition; the Uniform Plumbing Code, 2015 Edition; the Uniform Mechanical Code, 2015 Edition and the International Fire Code, 2015 Edition as adopted and

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interpreted by the State of New Mexico, 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.

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

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

National Electrical Manufacturer's Association Standards

National Electrical Code

Underwriters Laboratories, Inc. Standards

American National Standards Institute

American Society for Testing Materials Standards

Standards and requirements of local utility companies.

National Fire Protection Association Standards

American Society of Mechanical Engineers Boiler and Pressure Vessel Codes

Occupational Safety and Health Act

Commercial and Industrial Insulation Standards (MICA)

American Gas Association

The American Society of Sanitary Engineering

National Sanitation Foundation

1.4 RECORD DRAWINGS

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

B. The Contractor shall be responsible to maintain a complete and accurate set of marked up PDFs or prints showing information on the installed location and arrangement of all plumbing work, and in particular, where changes were made during construction. The Contractor shall be responsible for keeping record drawings accurate and up-to-date throughout the construction period. Record drawings may be reviewed and checked by the Architect during the construction and in conjunction with review and approval of monthly pay requests. Contractor shall include copies of all addenda, RFI's, bulletins, and change orders neatly taped or attached to record drawing set.

1.5 QUALIFICATIONS

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

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

1.6 QUALIFICATION PROCEDURES

- A. The storage, handling, and transportation of all refrigerants, oils, lubricants, etc. shall be accomplished in strict compliance with all State, local, and Federal Regulations including all requirements set forth by the Environmental Protection Agency (EPA) for the safe handling of regulated refrigerants and materials. The Contractor shall utilize qualified and/or certified personnel and equipment as prescribed by these requirements. In no situation shall any refrigerant be discharged to the atmosphere. All refrigerants recovered from all systems shall be returned to the owner.

1.7 HAZARDOUS CONDITIONS

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

1.8 HAZARD SIGNS

- A. Equipment rooms, fan plenums, and similar areas containing moving or rotating parts, or other potentially hazardous environments shall include signs on all doors entering such spaces that shall read similar to the following: "Hazardous Area - Authorized Personnel Only."
- B. Confined Spaces: Areas designated by OSHA Standard 1910.146 as a confined space shall be marked with a sign that reads "Confined Space - Entry by authorized personnel only, by permit."
 - 1. "Confined Space" means a space that:
 - a. Is large enough and so configured that an employee can bodily enter and perform assigned work; and
 - b. Has limited or restricted means for entry or exit (for example, tanks, vessels, storage bins, hoppers, vaults, and pits are spaces that may have limited means of entry); and
 - c. Is not designed for continuous employee occupancy.
- C. The Contractor shall survey the final premises to determine where any such potentially hazardous areas exist. If the Contractor feels that hazards exist which cannot be suitably provided for through the above typical methods, he shall forward in writing his concerns, and request for a decision concerning the referenced hazard, prior to the final inspection of the facilities.

1.9 SUBMITTALS

- A. The Contractor shall submit submittal brochures of all equipment, fixtures and materials to be furnished under Division 22, including but not limited to the following:
 - 1. Piping materials, valves, insulation materials and installation methods, vibration isolation devices, pipe penetration installation methods and products for fire rated assemblies, and all

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plumbing equipment listed on equipment schedules, and in related construction documents.

2. Materials, certification, shop drawings, and other information as specified in the individual Division 22 Specification Sections within this Specification.
- B. Unauthorized Substitutions: If substitute materials, equipment or systems are installed without prior review or are installed in a manner which is not in conformance with the requirement of this Specification and for which the Contractor has not received a written review, removal of all the unauthorized materials and installation of those indicated or specified shall be provided at no change in contract amount.
 - C. All equipment shall be installed in accordance with the manufacturer's recommendations. Provide all accessories and components for optimum operation as recommended by the manufacturer.
 - D. Expense: All costs for the preparation, correction, delivery, and return of the submittals shall be borne by the Contractor.
 - E. Complete data must be furnished showing performance, quality and dimensions. No equipment or materials shall be purchased prior to receiving written notification that submittals have been reviewed and marked either "NO EXCEPTIONS TAKEN" or "EXCEPTIONS AS NOTED." Submittals returned marked "EXCEPTIONS AS NOTED" do not require resubmittal provided that the Contractor agrees to comply with all exceptions noted in the submittal, and so states in a letter.
 - 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 minimum clearances required by applicable codes, manufacturer's installation instructions and as necessary for proper clearance in front of all electrical panels as defined by the National Electric Code (NEC). Any relocation of plumbing and/or electrical equipment, materials and systems required to comply with minimum clearances shall be provided by the Contractor without additional cost under the Contract.
 - G. Shop drawings will be returned unchecked unless the following information is included: cover sheet shall be provided for each submittal of equipment, products and material proposed for use on the project. A common cover sheet for similar equipment (example: all air handling units or all fire protection products) is acceptable. The cover sheet shall list equipment by symbol number; reference all pertinent data in the Specifications or on the drawings; provide size and characteristics of the equipment, name of the project and a space large enough to accept a review stamp. The data submitted shall reflect the actual equipment performance under the specified conditions and shall not be a copy of the scheduled data on the drawings. Cover sheet shall clearly identify any deviations from the specifications for submitted equipment, products, and materials.

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- 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 with the shop drawing submittals of the substitution. Failure to comply with this requirement will result in the shop drawings being returned unchecked.

1.10 COORDINATION DRAWINGS

- A. The Contractor shall, in advance of the work, prepare coordination drawings for:
 - 1. 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, 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

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structural items or with other construction items, such conflicts shall immediately be documented and submitted for clarification. In doing so, the Contractor shall explain the proposed method of solving the problem, or shall request instructions as to how to proceed if adjustments beyond those of usual trades coordination are necessary.

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

1.11 USE OF CADD FILES

- A. Under certain conditions, the Contractor will be permitted the use of the Engineer's CADD files for documentation of as-builts, submittals, or coordination drawings.
- B. The Engineer shall be compensated for the time required to format the CADD files for delivery to the Contractor. Such work may include removal of title blocks, professional seals, calculations, proprietary information, etc.
- C. The Contractor shall complete the enclosed License, Indemnity and Warranty Agreement, complete with contractor's name, address, and Contractor's Representative signature prior to request for CADD file usage.

1.12 PRIOR APPROVAL

- A. Prior approval (approval prior to bid) of alternate mechanical equipment suppliers and service providers is not required. Please do not request prior approval. Alternate manufacturers and 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.
- B. Equipment manufacturers and service providers are listed within the specifications for the work specified in this division. For the items listed below, the specified manufacturers and providers are the only ones presently approved, and may be the only ones allowed:
- C. 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.
- D. 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

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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.

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

1.13 GUARANTEE-WARRANTY

- A. 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.
- B. 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.
 - Hot Water Generators
 - Water Softeners

PART 2 PRODUCTS

2.1 QUALITY OF MATERIALS

- A. All equipment and materials shall be new, and shall be the standard product of manufacturers regularly engaged in the production of plumbing equipment and shall be the manufacturer's latest design. Specific equipment, shown in schedules on drawings and specified herein, is to set forth a standard of quality and operation.
- B. Hazardous or Environmentally Damaging Materials: Products shall not contain asbestos, mercury, PCS, or other materials harmful to people or the environment.

2.2 ALTITUDE RATINGS

- A. Unless otherwise noted, all specified equipment capacities are for an altitude of 5000 feet above sea level and adjustments to manufacturer's ratings must be made accordingly.

2.3 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, 460 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

- 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 5000 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

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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°C rise and total temperature rise of 65°C 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°C 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.

2.4 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.

2.5 PAINTING

- A. All finish painting of plumbing systems and equipment will be under "Painting," unless equipment is hereinafter specified to be provided with factory applied finish coats.
- B. All equipment shall be provided with factory applied prime finish, unless otherwise specified.
- C. Touch-Up: If the factory finish on any equipment is damaged in shipment or during construction of the building, the equipment shall be refinished.

2.6 COUPLING GUARDS

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

2.7 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.

2.8 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

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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:

<u>Outside Diameter of Pipe or Covering</u>	<u>Length of Color Field</u>	<u>Size of Letters</u>
----- 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. Attach pipe markers to lower quarter of the pipe on horizontal runs and on the centerline of vertical piping where view is not obstructed. Flow indicator arrow shall point away from pipe marker.

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

<u>Service/Legend</u>	<u>Letter Color</u>	<u>Background Color</u>
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

2.9 IDENTIFICATION OF CONTROL SYSTEM DEVICES

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

2.10 UNDERGROUND PIPING SYSTEM IDENTIFICATION

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

2.11 EQUIPMENT TAGS

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

2.12 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.
- 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.

PART 3 EXECUTION

3.1 COOPERATION WITH OTHER TRADES

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

3.2 DRAWINGS

- A. The plumbing drawings show the general arrangement of all piping, fixtures, equipment, etc., and shall be followed as closely as actual building construction and work of other trades will permit. Whenever discrepancies occur between plans and specifications, the most stringent shall govern. All Contract Documents, including but not limited to Division 21 Fire Suppression, Division 23 HVAC, and Division 26 Electrical shall be considered as part of the work insofar as this information furnishes the Contractor with details relating to design and construction of the building. Architectural and Structural drawings shall take precedence over the plumbing, HVAC and fire suppression drawings. Install plumbing fixtures, floor drains, floor sinks, roof drains, etc. in locations as indicated on Architectural drawings. Because of the small scale of the plumbing, HVAC and fire suppression drawings, it is not possible to indicate all offsets, fittings and accessories which may be required. The Contractor shall investigate the structural and finish conditions affecting the work and shall arrange his work accordingly, providing such fittings, valves, and accessories as may be required to meet such conditions. Should conditions necessitate a rearrangement of piping, such departures and the reasons therefore shall be submitted by the Contractor for review in the form of detailed drawings showing the proposed changes. No such changes shall be made without the prior written approval. All changes shall be marked on the set of record drawings by the Contractor.
- B. Should any doubt or question arise in respect to the true meaning of the drawings or specifications, the question shall be submitted in writing.
- C. Installation of all plumbing equipment and piping systems shall be arranged to provide all clearances required for equipment operation, service, and maintenance, including minimum clearances required by applicable codes, manufacturer's installation instructions and as necessary for proper clearance in front of all electrical panels as defined by the National Electric Code (NEC). Piping systems shall not be routed through or above electrical equipment room or electrical equipment space designed within equipment rooms.
- D. The 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.

3.3 FIELD MEASUREMENTS

- A. The Contractor shall verify the dimensions and conditions governing his work at the building. No extra compensation shall be claimed or allowed on account of differences between actual dimensions, including dimensions of equipment, fixtures and materials furnished, and those indicated on the drawings. Contractor shall examine adjoining work, on which his work is dependent for perfect efficiency, and shall report any work which must be corrected. Coordination of all plumbing work within the building will be the direct responsibility of the Contractor. Review of submittal data in accordance with paragraph "Submittals" shall in no manner relieve the Contractor of responsibility for the proper installation of the plumbing work within the available space. Installation of equipment and systems within the building space shall be carefully coordinated

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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;

3.4 EQUIPMENT SUPPORT

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

3.5 SEISMIC SUPPORTS

- A. The Contractor shall be responsible for all anchors and connections for the mechanical work to the building structure to prevent damage of equipment and systems due to earthquakes. The complete fire protection systems shall be supported as required to resist stresses produced by lateral forces as required by NFPA No. 13. Where mechanical equipment, piping, and ductwork 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 22 0548 for requirements for seismic supporting of plumbing equipment and systems.

3.6 PROTECTION OF MATERIALS AND EQUIPMENT

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

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- 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.

3.7 TRENCHING AND BACKFILLING

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

3.8 MANUFACTURER'S INSTRUCTIONS

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

3.9 CONCRETE BASES AND HOUSEKEEPING PADS

- A. Concrete bases and housekeeping pads shall be installed under all pieces of plumbing equipment unless specifically deleted by the specifications or drawings.
- B. Contractor shall be responsible for the accurate dimensions of all pads and bases and shall furnish and install all vibration isolators, anchor bolts, etc.
- C. Contractor shall provide concrete housekeeping pad foundations for all floor mounted equipment installed under this section unless otherwise shown on the drawings. All concrete bases and housekeeping pads shall conform to the requirements specified under Division 3, Concrete, portions of these specifications. Pad foundations shall be 4" high minimum, unless otherwise indicated on the drawings. Chamfer edges shall be 1". Faces shall be free of voids and rubbed smooth with carborundum block after stripping forms. Tops shall be level. Provide dowel rods in floor for lateral stability and anchorage.
- D. Equipment anchor bolts shall be set in a galvanized pipe or sheet metal sleeves 1" larger than bolt diameter. Anchor bolts shall be high strength steel J shape. Anchor bolt design shall be arranged and paid for by the Contractor.
- E. Machinery bases, bed plates, sole plates, or vibration isolation units shall be carefully aligned, shimmed, leveled, then grouted in place with commercial non-shrink grout. When a flexible coupling is employed as a part of the drive train, the coupling shall be aligned before the machinery base is grouted.

3.10 ALIGNMENT OF FLEXIBLE COUPLINGS

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

3.11 LUBRICATION

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

3.12 PRESSURE RELIEF DEVICES

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

3.13 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**.

3.14 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.

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- C. Equipment requiring installation check includes the following:
 - End Suction Pumps
 - Domestic Water Heaters

3.15 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. 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.
- C. Upon completion of all work and all tests, Contractor shall furnish the necessary skilled labor and helpers for operating the plumbing systems and equipment for a period of five (5) days of eight (8) hours each. During this period, the Contractor shall instruct the Owner or his representative fully in the operations, adjustment and maintenance of all equipment furnished. Contractor shall provide at least two weeks notice in advance of this period, with a written schedule of each training session, the subject of the session, the Contractors' representatives who plan to attend the session, and the time for each session.
- D. Operational test shall be conducted by the Contractor with the assistance of the equipment manufacturer's representative or service technician. Test shall be conducted in the presence of the designated and authorized Owner's Representative.

3.16 CERTIFICATIONS

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

3.17 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.

3.18 PLUMBING SYSTEM SHUTDOWN AND REACTIVATION

- A. The Contractor shall shutdown existing facility plumbing equipment and piping systems as required

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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.

3.19 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

Project: _____ Date Submitted: _____

General Contractor: _____ Date of Final Mechanical System: _____

Mechanical Contractor: _____ Observation Requested: _____

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

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

HVAC/PIPING

- _____ 1. All plumbing fixtures are set, sealed and cleaned.
- _____ 2. All domestic pipe systems are insulated.
- _____ 3. All pipe systems are identified with specified labels and directional arrows.
- _____ 4. Floor sinks and drain grates are cleaned and debris removed.
- _____ 5. Valve tags are installed.
- _____ 6. Special equipment (water softeners, water heaters, piping systems, etc.) have been checked and put into service.
- _____ 7. Medical gas systems have been checked and certified.
- _____ 8. Special piping systems have been cleaned and pressure tested.
 - _____ Process Piping _____ Nitrogen
 - _____ Compressed Air _____ Vacuum
 - _____ Natural Gas _____ Argon
 - _____ Other _____ Medical Gas
 - _____ _____ Other
- _____ 9. Limestone chips have been installed in acid dilution sumps.
- _____ 10. Plumbing/piping connections have been completed to Owner furnished equipment and equipment furnished by other Contractors/Sub-Contractors.
- _____ 11. Exterior wall hydrants have been cleaned.
- _____ 12. Concrete collars have been installed at clean-out to grade, valve box, or other specified plumbing items.
- _____ 13. Drains and relief lines from plumbing equipment have been installed and secured in a proper manner.
- _____ 14. All plumbing equipment and areas of equipment have been cleaned and debris removed.
- _____ 15. All plumbing equipment required by the Specifications has been identified and/or numbered.
- _____ 16. Domestic water systems sterilization has been completed.
- _____ 17. Strainers/suction diffusers have been cleaned.
- _____ 18. Backflow preventers have been tested.
- _____ 19. Air has been vented from all systems.

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- _____ 20. Ethylene glycol system has been charged with correct mixture and tested.
- _____ 21. Water systems have been cleaned (X) and pressure tested (P).
 - _____ Non-potable Water _____ Domestic Hot Water
 - _____ Domestic Cold Water _____ Acid Waste and Vent
 - _____ Sanitary Sewer & Vent _____ Roof and Overflow Drains
 - _____ Other (list)
- _____ 22. PRV's have been adjusted (water, gasses).

PLUMBING EQUIPMENT

- _____ 1. All pump shafts and couplings have been aligned.
- _____ 2. Boilers and domestic water heaters have been fired and tested.
- _____ 3. All plumbing equipment has been lubricated.
- _____ 4. Plumbing equipment has been labeled in accordance with the specifications.
- _____ 5. "HAZARDOUS AREA" signs installed where applicable.
- _____ 6. Variable frequency drives have been tested by the manufacturer's representative and certified to be in compliance with all of the specified requirements.

GENERAL ITEMS

The following specified items have been submitted:

- _____ 1. Record drawings (to be submitted prior to final payment to the Contractor).
- _____ 2. Operation and maintenance manuals.
- _____ 3. Manufacturer's representative installation check and certification submitted (see list of equipment, Section 22 0500).
- _____ 4. Test kits furnished to Owner.
 - _____ Flow Measuring Devices
 - _____ Flow Balance Valves
 - _____ Flow Control Devices
- _____ 5. Control schematics and sequence of operation.
- _____ 6. Plumbing equipment and lubrication, valve, charts have been provided to Owner's Representative.

END CHECKLIST

DIVISION 22 SUBSTITUTION REQUEST FORM (SRF)

TO: BRIDGERS & PAXTON CONSULTING ENGINEERS, INC.

PROJECT: _____

We hereby submit for your consideration the following product instead of the specified item for the above project:

Section: _____ Page: _____ Paragraph/Line: _____ Specified Item: _____

Proposed Substitution: _____

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

1. Will changes be required to building design in order to properly install proposed substitutions? YES NO

If YES, explain: _____

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

3. List differences between proposed substitutions and specified item.

Specified Item	Proposed Substitution
_____	_____
_____	_____
_____	_____

4. Does substitution affect Drawing dimensions? YES NO

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

6. Does the manufacturer's warranty for proposed substitution differ from that specified? YES NO

If YES, explain: _____

7. Will substitution affect progress schedule? YES NO

If YES, explain: _____

8. Will maintenance and service parts be locally available for substitution? YES NO

If YES, explain: _____

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

SUBMITTED BY: Firm: _____ Date: _____

Address: _____

Signature: _____ Telephone: _____

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

LICENSE AGREEMENT FOR CADD DATABASE OR BIM MODEL

PROJECT: _____

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

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

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

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

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

CONTRACTOR'S REPRESENTATIVE

Signature: _____ Company Name: _____

Name: _____ Address 1: _____

Title: _____ Address 2: _____

Date: _____

SECTION 22 0503 - TRENCHING AND BACKFILLING FOR PLUMBING

PART 1 GENERAL

1.1 REQUIREMENTS

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

1.2 SCOPE OF WORK

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

PART 2 PRODUCTS

Not Applicable.

PART 3 EXECUTION

3.1 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.

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- 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. 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.

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- 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 33.
- M. The Contractor shall protect from damage all existing underground utilities indicated on the Contract Drawings or field located by underground utility locator service by the Owner prior to excavation operation. 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 33 requirements.

END OF SECTION

SECTION 22 0504 PIPE AND PIPE FITTINGS FOR PLUMBING

PART 1 GENERAL

1.1 REQUIREMENTS

- A. Conform with applicable provisions of the General Conditions, Supplemental General Conditions and General Requirements.
- B. Lead Ban: All systems and system components, pipe, fittings, and fixtures delivering water for human consumption shall be lead free.
 - 1. Any product designed for dispensing potable water shall meet both the NSF 61 and NSF 372 test standards via third-party testing and certification.
 - 2. Lead free refers to <0.25% weighted average lead content in relation to wetted surface of pipe, fittings, and fixtures in systems delivering water for human consumption, and solder and flux which does not contain more than 0.2% lead.

1.2 RELATED SECTIONS

- A. Section 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, seismic restraints, pipe sleeves including sealing and fire safing materials and installation.

PART 2 PRODUCTS

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

PART 3 EXECUTION

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

END OF SECTION

SECTION 22 0505 PIPING SPECIALTIES FOR PLUMBING

PART 1 GENERAL

1.1 REQUIREMENTS

- A. Contractor shall furnish and install all piping specialties necessary for satisfactory operation of the systems. Conform with applicable provisions of the General Conditions, Supplemental General Conditions and General Requirements.
- B. Lead Ban: All systems and system components, pipe, fittings, and fixtures delivering water for human consumption shall be lead free.
 - 1. Any product designed for dispensing potable water shall meet both the NSF 61 and NSF 372 test standards via third-party testing and certification.
 - 2. Lead free refers to <0.25% weighted average lead content in relation to wetted surface of pipe, fittings, and fixtures in systems delivering water for human consumption, and solder and flux which does not contain more than 0.2% lead.

1.2 RELATED SECTIONS

- A. Section 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.

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PART 2 PRODUCTS

See Division 23, Section 23 0505, Piping Specialties.

PART 3 EXECUTION

See Division 23, Section 23 0505, Piping Specialties.

END OF SECTION

SECTION 22 0523 VALVES FOR PLUMBING

PART 1 GENERAL

1.1 REQUIREMENTS

- A. All Valves shall conform with current applicable provisions of the General Conditions, Supplemental General Conditions, and General Requirements.
- B. All Valves shall meet the current MSS Specifications covering Bronze & Iron Valves. MSS-SP-80, MSS-SP-70, MSS-SP71, MSS-SP-85 where applicable.
- C. Lead Ban: All systems and system components, pipe, fittings, and fixtures delivering water for human consumption shall be lead free.
 - 1. Any product designed for dispensing potable water shall meet both the NSF 61 and NSF 372 test standards via third-party testing and certification.
 - 2. Lead free refers to <0.25% weighted average lead content in relation to wetted surface of pipe, fittings, and fixtures in systems delivering water for human consumption, and solder and flux which does not contain more than 0.2% lead.

1.2 RELATED SECTIONS

- A. Section 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.

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- C. Ball valves shall be utilized in lieu of gate valves and globe valves for all plumbing systems for sizes 2" and smaller.
- D. All valves furnish under Division 22 and 23 of the same type shall be products of a single manufacturer unless otherwise approved by Owner's Representative.
- E. Provide gate and globe valves with packing that can be replaced with the valve under full working pressure.

PART 2 PRODUCTS

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

PART 3 EXECUTION

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

END OF SECTION

SECTION 22 0548 VIBRATION AND SEISMIC CONTROLS FOR PLUMBING

PART 1 GENERAL

1.1 REQUIREMENTS

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

1.2 RELATED SECTIONS

- A. Section 21 0500, Common Works Requirements for Fire Suppression.
- B. Section 22 0504, Pipe and Pipe Fittings for Plumbing.
- C. Section 22 0551, Instrumentation and Controls for Plumbing.
- D. Section 22 1100, Domestic Water Piping.
- E. Section 22 1316, Sanitary Waste and Vent Piping.
- F. Section 22 1400, Facility Roof and Area Drainage.
- G. Section 22 6000, Medical Gas and Vacuum Systems for Healthcare Facilities.

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 22 0500 for general requirements for submittal materials. In addition to the requirements contained in Section 22 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' of this section must submit for prior approval in accordance with provisions contained in Section 22 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 22 of this Specification in accordance with the requirements of the 2012 International Building Code as adopted and interpreted by the State of New Mexico.
- B. Performance requirements:
 - 1. Risk Category = IV.
 - 2. Site Class = D.

1.6 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 plumbing equipment and piping systems are properly supported to resist earthquake forces as required herein.
- B. All plumbing 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 plumbing equipment required for life safety 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.

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- D. All items of plumbing equipment, except as specified above, and all piping furnished and installed under Division 22 shall be provided with seismic restraints securely anchored to the building capable of resisting horizontal forces of 50% of their weight.
- E. Seismic restraint/snubber manufacturer shall be responsible for the structural design of attachment hardware as required to attach seismic restraints/snubbers to both the equipment and supporting structure on vibration isolated equipment, or to directly attach equipment to the building structure for non-isolated equipment.
- F. The Contractor shall furnish a complete set of approved shop drawings of all mechanical and electrical equipment which is to be restrained to the seismic restraint manufacturer, from which the selection and design of seismic restraint devices and/or attachment hardware will be completed. The shop drawings furnished shall include, at a minimum, basic equipment layout, length and width dimensions, installed operating weights of the equipment to be restrained and the distribution of weight at the restraint points.

PART 2 PRODUCTS

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

PART 3 EXECUTION

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

END OF SECTION

SECTION 22 0549 PLUMBING AND ELECTRICAL INSTALLATION COORDINATION

PART 1 GENERAL

1.1 REQUIREMENTS

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

1.2 RELATED DIVISIONS AND SECTIONS

- A. Section 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.

PART 2 PRODUCTS

Not Applicable

PART 3 EXECUTION

3.1 INSTALLATION

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

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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 [25]
Stand Alone Motor Starters (outside motor control centers)	(1)	Div. 26	Div. 26	Div. 26	Div. 23 [25]
Variable Frequency Drives (VFD's)		Div. 22	Div. 22	Div. 26	Div. 23 [25]
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 [25]
Boilers & Domestic Water Heaters		Div. 22	Div. 22	Div. 26	Div. 23 [25]
Pressure Booster Pump Systems		Div. 22	Div. 22	Div. 26	Div. 23 [25]
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 [25]
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

SECTION 22 0700 PLUMBING INSULATION

PART 1 GENERAL

1.1 REQUIREMENTS

- A. Conform with applicable provisions of the General Conditions, Supplemental General Conditions and General Requirements.
- B. Materials shall conform to applicable ASTM standards.

1.2 RELATED SECTIONS

- A. Section 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, 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. Equipment covering, including heat exchangers, storage tanks, pumps, domestic hot water boiler stacks and breeching, domestic water heater stacks and breeching.

1.4 FITTINGS

- A. All fittings except as otherwise specified, shall be insulated with the same material and thickness as specified for the pipe.
- B. Unions, flanges and valves on hot water, will not require insulation.

1.5 TESTING

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

PART 2 PRODUCTS

2.1 INSULATION

- A. Insulation shall be as manufactured by Owens-Corning Fiberglas, Knauf, CertainTeed, Johns Manville, or Armstrong, or equivalent, and shall be equal to that specified below. Insulation and all materials on the interior and exterior surfaces of ducts, pipes, and equipment shall have a composite fire and smoke hazard rating not exceeding: Flame spread - 25; fuel contribution - 50; smoke developed - 50, as determined in accordance with ASTM Standard E-84. All insulation materials used for valves and fittings shall have the same ratings as the pipe insulation. Information must be submitted by means of manufacturer's literature showing that the proposed materials conform to above specification without exception.
- B. Fiberglass pipe insulation shall be rigid molded and non-combustible with 'K' factor of 0.23 at 75°F. Jacket shall be all service (ASJ) vapor barrier jacket with white kraft paper reinforced with glass fiber yarn and bonded to aluminum foil, secured with self sealing longitudinal laps and butt strips. Johns Manville 'Micro-Lok' or equivalent.
- C. Hydros Calcium Silicate insulation shall be rigid molded, non-combustible per ASTM E 136, conforming to ASTM 533, asbestos-free with 'K' factor of 0.40 at 300°F., maximum service temperature 1200°F., compression strength (block) minimum of 200 PSI to produce 5% compression at 1-1/2" thickness. Johns Manville 'Thermo-12 Gold' or equivalent.
- D. Fiberglass rigid board insulation for equipment shall conform to ASTM C612 with 'K' factor of 0.23 at 75°F, R=8.0 minimum, 3.0 pound per cubic foot density. Provide vapor barrier jacket (FSK) with aluminum foil reinforced with fiberglass yarn and laminated to fire-resistant kraft, secured with UL listed pressure sensitive tape and outward clinched expanded staples and vapor barrier mastic. Johns Manville 'Spin-Glas' or equivalent.
- E. Elastomeric foam insulation for piping and equipment shall be flexible, cellular, molded or sheet, conforming to ASTM C534, with 'K' factor of 0.28 at 75°F., maximum service temperature of 220°F., maximum flame spread rating of 25 and maximum smoke development rating of 50 (3/4" thickness and less). Connections shall be made using manufacturer's approved waterproof vapor barrier retarder adhesive. Provide outdoor U.V. protective coating on all insulation exposed to ambient conditions.

2.2 FITTINGS

- A. Valves and fittings, where required to be insulated, shall be covered with the same insulation material and thickness as specified for the pipe insulation and finished with PVC covers.
- B. Valves and fittings with systems specified to be covered with metal or canvas, or polyvinyl chloride (PVC) jacket shall be covered with material to match piping system jacketing.
- C. Polyvinyl chloride (PVC) preformed fitting covers with fiberglass inserts shall be used on valves and fittings, except where metal or canvas jacket is required for piping system. PVC fitting covers shall be Zeston 2000 or equivalent, gloss white and shall have a composite fire

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and smoke hazard rating not exceeding; flame spread - 25; smoke development - 50. Connections shall be made using tacks and pressure sensitive color matching vinyl tape. Seams shall be on the bottom side of pipe and fittings.

2.3 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 embossed 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.

2.4 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.

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

2.5 PIPE SLEEVES

- A. See Specification Section 22 0504 for requirements associated with pipe sleeves for piping penetrations for building walls and frames.

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

PART 3 EXECUTION

3.1 DOMESTIC HOT WATER PIPING

- A. Domestic hot water piping with operating temperatures of 140°F and less, including 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. All voids formed by support saddles or other mounting or support hardware shall be filled with insulation.

3.2 DOMESTIC COLD WATER AND ROOF DRAINS

- A. Domestic cold water piping shall be insulated with 1-inch thick fiberglass preformed pipe insulation with All Services Jacket (ASJ). Fittings shall be finished with PVC fitting covers.
- B. Roof drain bowls and horizontal roof drain piping shall be insulated with 1-inch thick fiberglass insulation as specified for domestic cold water piping.
- C. Overflow roof drain bowls and horizontal overflow roof drain piping shall be insulated with 1-inch thick fiberglass insulation as specified for domestic cold water piping.
- D. All voids formed by support saddles or other mounting or support hardware shall be filled with insulation.

3.3 HANDICAP LAVATORY AND SINKS

- A. Domestic hot and cold water piping and P-traps exposed below handicapped lavatories and sinks shall be insulated with HANDI LAV-GUARD insulation kits which satisfy ANSI A117.1 requirements. Insulation shall have a flexible vinyl finish which protects against burning and cushions impact.
- B. Countertop sinks indicated within the Architectural drawings to be handicap-compliant shall have an off-centered drain opening and a maximum sink depth of 7-inches.

3.4 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.
- 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.

3.5 PVC JACKETING

- A. PVC jacketing shall be installed on all field insulated plumbing equipment and on all piping systems exposed within the mechanical equipment spaces, that are installed below 8 feet above the floor, where exposed to physical damage, inside accessible tunnels, and where noted on the drawings and specifications, except where metal or canvas jacketing is required.
- B. Jacketing shall be secured in place in an approved manner by means of tacks and pressure sensitive tape.
- C. Fittings and valves shall have insulation covered with PVC pre-molded PVC fittings to match jacketing, as specified below.
- D. PVC jacketing shall not be permitted for use on exterior piping systems.

3.6 TERMINATION OF INSULATION

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

3.7 FACTORY INSULATED EQUIPMENT

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

3.8 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.

3.9 BOILER STACKS AND BREACHING

- A. Domestic hot water boiler and water heater stacks and breaching shall be insulated with 4" thick calcium silicate as specified in Paragraph 2.1.C and finished with metal jacketing.

3.10 VESSELS, TANKS, AND EQUIPMENT

- A. Insulate hot vessels, tank, and equipment, including, etc., with 1" thickness, 3 pound density fiberglass insulation for surface temperatures from 40°F to 60°F, 2" thickness, 3 pound density fiberglass insulation for surface temperatures from 60°F to 400°F, and 4" thickness, calcium silicate insulation for surface temperatures in excess of 400°F to 1200°F. Insulation board shall be scored, beveled, or mitered to provide tight joints and shall be secured in place by mechanical pin and clip fasteners and insulation bonding adhesive applied to underside surfaces or with bands. All joints, cracks, seams and voids shall be filled with insulation bedding compound and finished to smooth surface, provide corner beads to protect edges of insulation. Cover insulation with canvas jacket as specified herein. Cover insulation with metal jacket as specified herein. Stretch 1" mesh wire, with edges laced together over insulation and finished with insulating and finishing cement applied in one coat, 1/4" thick, and troweled to a smooth finish. Bevel insulation away from all flanges, nameplates, and access fittings. Provide removable and re-usable insulation cover for all access fittings and manhole covers.

END OF SECTION

SECTION 22 1100 DOMESTIC WATER PIPING

PART 1 GENERAL

1.1 REQUIREMENTS

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

1.2 RELATED SECTIONS

- A. Section 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.

1.3 SCOPE

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

PART 2 PRODUCTS

2.1 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. Domestic water piping 6" and larger below grade within the building and to a point approximately 5'-0" from the building shall be ductile iron pressure pipe, minimum 150 PSIG working pressure with mechanical joints.
- B. Domestic water piping above grade within the building 4" and smaller shall be Type L hard drawn copper, ASTM B88. Domestic water piping larger than 4" shall be copper as specified herein or flanged ductile iron pipe.
- C. Proper insulating fittings, as specified in Section 22 0504, shall be installed to prevent electrolytic action between steel and copper piping connections.

2.2 FITTINGS

- A. Fittings for copper piping shall be wrought copper or cast brass conforming to ANSI B16.22 and B16.23, with 95-5 solder joints, as specified in Section 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.
- D. Fittings for ductile iron pipe shall be flanged or mechanical joint conforming to ANSI/AWWA C110 and C111, Class 250 minimum, cement lined, with bituminous coating.

2.3 FLANGES

- A. Flanges for copper piping systems shall be Class 150 wrought copper or cast brass conforming to ANSI B16.24.
- B. Flange connections for valves and equipment shall match the rating and drilling of the valves and equipment furnished.
- C. Flanges for galvanized steel piping system shall be galvanized cast or malleable iron Class 125, standard threaded plain face companion flanges for flanged connections in threaded piping systems.
- D. Gaskets shall be 1/16" thick ring type or full face non-asbestos material suitable for the temperatures and pressure application.
- E. Flange bolting shall be carbon steel machine bolts or studs and hex nuts, ASTM A307, Grade B.

2.4 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.

2.5 SHOCK ABSORBERS

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

2.6 DOMESTIC HOT WATER GENERATING EQUIPMENT

- A. Water heaters and associated auxiliary equipment shall be as specified on the equipment schedule on the drawings. Natural gas fired or electric domestic water heaters shall be as manufactured by Bock, Bradford-White, Lochinvar, P.V.I., Ruud, Rheem, A.O. Smith, State, or equivalent.
- B. Electric instantaneous water heaters shall be by Chronomite, Eemax, Hubbell, Keltech, Rheem, Stiebel Eltron, State, or equivalent.
- C. Natural gas fired domestic hot water boilers and water heater combustion flues, stack, breeching, and combustion air louvers, ducts, etc., shall be provided under Division 23.

2.7 VALVES

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

2.8 PUMPS

- A. Pumps shall be of the type and capacity listed in the equipment schedule. Pumps shall be selected so that the motors will not overload under any operating condition. Furnish one spare mechanical seal of each size required in conjunction with the pumps furnished under this Contract. All base mounted pumps shall have drain pans with tapped pipe connections and 3/4" drain line extended to floor drain. Pumps shall be installed so that they may be removed

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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.
- C. Manufacturer shall furnish a full one (1) year warranty, including all parts and labor for the water pressure booster pumping system.

2.9 WATER METER

- A. Domestic water meter assembly shall be furnished by the City of Rio Rancho. Meter size and general arrangement shall be as indicated on the drawings. The Contractor shall coordinate with the applicable representatives for the installation of the water meters and shall furnish all associated piping, valves and materials, including meter box/vault, in accordance with details on the drawings and applicable Requirements.
- B. 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.
- C. Water meters shall be installed by the Contractor.

2.10 BACKFLOW PROTECTION

- A. All cross-contamination control shall be provided to ensure that no installation of the potable water supply piping system shall be made in a manner that will allow used, unclean, polluted, or contaminated water or substances to enter the domestic potable water system.
- B. All backflow devices and assemblies shall be approved by the applicable Administration Authorities and shall be installed according to all applicable codes, regulations, and manufacturer's instructions. Installation shall allow for required access and clearance for required testing, maintenance, and repair.
- C. Reduced pressure backflow preventer assembly shall be furnished and installed by the Contractor. Backflow preventer size and arrangement shall be as indicated on the drawings, and shall be as manufactured by Febco, Hersey, Beeco, Watts, Wilkins, or equivalent. All costs, fees, and permits required shall be secured and paid for by the Contractor, unless otherwise indicated.
- D. See Section 23 0504 for backflow preventer required for make-up water connections to HVAC systems.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Piping installation shall conform to the requirements of Section 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.

3.2 STERILIZATION

- A. All new water piping shall be charged with a chlorine solution containing not less than 50 PPM available chlorine. The solution shall remain in the piping for a period of 24 hours, during which time valves shall be opened and closed to permit a small flow of the solution. At the end of 24 hours, the solution shall be tested and must contain a residual of at least 5-10 PPM chlorine. The system shall then be drained and flushed to provide satisfactory potable water before final connection is made to the existing distribution system.
- B. The Contractor shall submit a sample of the water, after sterilization and flushing for testing by an approved laboratory. A copy of the acceptable test report shall be submitted to the Architect prior to substantial completion.

3.3 BACKFLOW PROTECTION

- A. Protection: All plumbing fixtures, faucets with hose connections, and all other equipment having plumbing connections shall have their water supplies protected against back-siphonage.
- B. Testing: Arrange for testing backflow devices as required by the local health authorities.

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3.4 TESTS

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

END OF SECTION

SECTION 22 1123 FACILITY NATURAL GAS SYSTEM

PART 1 GENERAL

1.1 REQUIREMENTS

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

1.2 RELATED SECTIONS

- A. Section 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.

1.3 SCOPE

- A. Complete building natural gas piping system including meters, regulators, and miscellaneous accessories.

PART 2 PRODUCTS

2.1 PIPING

- A. Above ground pipe used for the installation, extension, alteration, and/or repair of any gas piping system shall be black steel pipe ASTM A53 Grade A or B, ERW or BW, standard wall, Schedule 40.
- B. All underground gas piping shall be steel or polyethylene plastic piping as specified in Section 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, and Section 22 6801, Outside Utilities, Plumbing.

2.2 FITTINGS

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

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

2.3 FLANGES

- A. Flanges for steel piping system shall be forged steel, weld neck, or slip-on, 1/16" raised face Class 150 flanges conforming to ANSI B16.5.
- B. Flange connections for valves and equipment shall match the rating and drilling of the valves and equipment furnished.
- C. Where specifically required by the application, black cast iron Class 125 standard threaded plain face companion flanges may be utilized for flanged connections in threaded piping systems.
- D. Gaskets shall be 1/16" thick full face non-asbestos material suitable for the temperatures and pressure application.
- E. Flange bolting shall be carbon steel machine bolts or studs and hex nuts, ASTM A307, Grade B.

2.4 VALVES

- A. Valves shall be as specified in Section 22 0523, Valves for Plumbing.
- B. Valves used in conjunction with gas piping shall be approved for the required service.

2.5 SEISMIC SHUT-OFF VALVE

- A. Seismic earthquake actuated automatic gas shut-off valve shall automatically actuate (close) when subject to a horizontal sinusoidal oscillation having a peak acceleration of 0.3 G and a period of 0.4 seconds, or as otherwise required by the authority having jurisdiction. Valve shall not be sensitive to vibrations caused by passing trucks or accidental bumping. Valve shall provide positive sealing from -10°F to 150°F, and shall have a visual open-close indicator and manual reset. Valve shall be UL listed and FM approved, and shall be AGA and IAPMO approved. Valves 3/4" through 1-1/2" shall be NPT connections and 2" size and larger shall be Class 125 flange connections. Valve shall be installed on downstream side of meter and regulator station in an accessible location outside the building, and shall be installed and securely supported with uni-strut brackets as recommended by the manufacturer. Valves for low pressure gas application shall have a 0.5 PSIG maximum pressure rating, and valve for high pressure gas application shall have a 20 PSIG maximum pressure rating. Valves shall be as manufactured by KOSO, Safe T Quake, SISMO, Quick Master, or equivalent.

2.6 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

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

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

2.8 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.

2.9 PAINTING

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

PART 3 EXECUTION

3.1 INSTALLATION

- A. Piping installation shall conform to the requirements of Section 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

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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.

3.2 EQUIPMENT AND APPLIANCE CONNECTIONS

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

3.3 DRIPS

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

3.4 VENTS

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

3.5 TESTS

- A. All gas piping shall be pressure tested using air, 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 Rio Rancho and State of New Mexico and NFPA No. 54.

END OF SECTION

SECTION 22 1400 FACILITY ROOF AND AREA DRAINAGE

PART 1 GENERAL

1.1 REQUIREMENTS

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

1.2 RELATED SECTIONS

- A. Section 22 0500, Common Work Requirements for Plumbing.
- B. Section 22 0504, Pipe and Pipe Fittings for Plumbing.
- C. Section 22 0700, Plumbing Insulation.

1.3 SCOPE

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

PART 2 PRODUCTS

2.1 PIPING

- A. Pipe, fittings and couplings below grade or slab-on-grade shall be service weight cast iron no hub pipe, coated inside and outside, conforming to ASTM A-74 and 87 Standards, 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 pipe, coated inside and outside, conforming to ASTM A-74 and 87 Standards.
- C. No-hub cast iron pipe shall conform to CISPI Standard 301 and shall be marked with CISPI Label.
- D. All above and/or below ground cast iron pipe and/or fittings shall be marked with the trademark of the Cast Iron Soil Pipe Institute.

2.2 FITTINGS

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

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- B. Fittings for galvanized steel pipe shall be screwed galvanized cast iron or malleable iron drainage pattern.

2.3 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.

2.4 DRAINS

- A. Roof drains, 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.

2.5 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.

2.6 ACCESSORIES

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

PART 3 EXECUTION

3.1 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.

3.2 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

SECTION 22 4000 PLUMBING FIXTURES AND TRIM

PART 1 GENERAL

1.1 REQUIREMENTS

- A. Conform with applicable provisions of the General Conditions, Supplemental General Conditions and the General Requirements.
- B. Lead Ban: All systems and system components, pipe, fittings, and fixtures delivering water for human consumption shall be lead free.
 - 1. Any product designed for dispensing potable water shall meet both the NSF 61 and NSF 372 test standards via third-party testing and certification.
 - 2. Lead free refers to <0.25% weighted average lead content in relation to wetted surface of pipe, fittings, and fixtures in systems delivering water for human consumption, and solder and flux which does not contain more than 0.2% lead.

1.2 RELATED SECTIONS

- A. Section 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.

PART 2 PRODUCTS

2.1 FIXTURES AND EQUIPMENT

- A. Vitreous china and enameled cast iron fixtures by American Standard, Kohler, Sloan, Zurn, Mansfield, Toto, or equivalent as listed and described in the plumbing fixture schedule on the drawings. All vitreous china and enameled cast iron fixtures shall be white, unless otherwise indicated on the drawings. The material used for plumbing fixtures shall be of non-absorptive, acid-resistant vitreous china, enameled cast iron or stainless steel, and free from all imperfections. Lavatories and sinks required in patient care areas shall have the water spout mounted so that the discharge point is a minimum distance of 5" above the rim of the fixture. Where blade handles are used, they shall not exceed 4-1/2" in length except that handles on scrub sinks and clinical sinks shall be not less than 6" long. Clinical sinks shall have an integral trap in which the upper portion of a visible trap seal provides a water surface. Each water service main, branch main, riser and branch to a group of fixtures shall be valved or as otherwise shown on the drawings to provide more stringent requirements. Stop valves shall be provided at each fixture. One piece chrome plated escutcheons shall be installed on all water piping and trap

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connections at walls or base cabinets. All exposed connecting piping and material shall be chrome plated.

- B. Handicap accessible lavatories and counter mounted sinks shall have exposed supply and waste services insulated with rigid, molded insulation kits as manufactured by T.C.I. "Skal-Gard", Brocar "Trap Wrap", True-Bro "Handi Lav-Guard", McGuire "Prowrap", or equivalent. Provide off-set tail piece fittings on all handicap accessible laboratories and sinks as required.
- C. Flush valves shall be low water consumption type as specified on drawings. Valves shall be diaphragm or piston type, with metal oscillating non-hold open handle, screw driver back check angle stop assembly with cap, adjustable tailpiece, vacuum breaker flush connection, and spud couplings as required for wall and fixture rough-in. Exposed flush valves shall be fully chrome plated, with chrome plated supply pipe cover. Flush valves shall be 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, Designer's Choice, 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. Electric water coolers (EWC) and 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.
- I. Shower valves and mixing valves shall be as specified on the Plumbing Fixture Schedule on the drawings, and as manufactured by Powers, Leonard, Lawler, Speakman, Symmons, Bradley, or equivalent.

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

2.2 FAUCETS

- A. Plumbing fixture faucets shall be brass construction and fully chrome plated, unless special finish is specified on the Plumbing Fixture Schedule on the drawings. Faucets shall be furnished complete with all accessories required for the necessary application, including aerators, handles, spouts, and operating cartridges. Contractor shall coordinate exact faucet requirements with required fixture drilling and water and waste rough-in. Faucets for handicapped fixtures shall meet all handicapped and ADA requirements, including a maximum of five (5) pounds of force to activate controls and adjustable metering faucet water flow duration of ten (10) seconds, minimum. Single hole faucets shall have anti-clocking pin to prevent rotation of valve body.
- B. Plumbing fixture faucets shall be furnished by the fixture manufacturer as specified in the Plumbing Fixture Specification on the drawings and Paragraph 2.1 herein, or shall be as manufactured by Chicago, Delta, Moen, Speakman, T&S Brass, Zurn, or equivalent, and shall be commercial grade.

2.3 PLUMBING FIXTURE TRIM

- A. Plumbing fixture trim including P-traps, supplies, and strainers shall be furnished by the fixture manufacturer as specified in the Plumbing Fixture Specification on the drawings and Paragraph 2.1 herein, or shall be as furnished by Chicago, Brass Craft, McGuire, T&S Brass, EBC, Zurn, or equivalent.
- B. Unless otherwise specified, traps shall be copper-alloy adjustable tube-type with slip joint inlet and swivel, not less than 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.

PART 3 EXECUTION

3.1 INSTALLATION

- A. The Contractor shall provide all necessary supports and connection materials and trim for plumbing fixtures as required to assure a complete properly installed and operating system. Installation shall be in accordance with manufacturer's recommendations and with Uniform Building Code and Uniform Plumbing Code requirements. The Contractor shall caulk fixtures to the adjacent wall, floor and countertop construction with non-shrink, mildew resistance caulking material.
- B. Fixture mounting height shall conform to the ADA Accessibility Requirements and coordinated with the Architectural drawings.
 - 1. ADA required Water Closet shall be mounted with 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 or Water Coolers spouts shall be no higher than 36" measured from the floor or ground surface to the spout outlet.

3.2 EQUIPMENT/FIXTURE SUPPORT

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

3.3 FIXTURE CARRIERS

- A. Fixture carriers shall be provided for all wall hung plumbing fixtures, including 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.

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- 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.

3.4 FOOT PEDALS

- A. Plumbing fixture foot pedals, when specified, shall be provided with required back-up support and shall not be installed until wall support methods have been submitted for review.

3.5 EQUIPMENT FURNISHED BY OTHERS

- A. The Contractor shall furnish and install complete rough-in and connections, including stop valves on all supply piping for all mechanical services required for equipment furnished and installed under other sections of this specification, and for all owner-furnished equipment.
- B. Types of equipment in this category shall include but not be limited to the following: kitchen equipment, shop equipment, hospital and laboratory casework, medical equipment, etc. The Contractor shall provide all pipe fittings, unions, traps, connecting wastes, valves, cocks, regulators, pressure reducing valves, flexible connectors, etc., as required for the services to each piece of equipment.
- C. Installation and setting of equipment and fixtures furnished under other Sections of this Specification will not be provided under Division 22 of this Specification, unless otherwise indicated.

3.6 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.

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3.7 CLEANING

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

END OF SECTION

SECTION 23 0500 COMMON WORK REQUIREMENTS FOR HVAC

PART 1 GENERAL

1.1 SCOPE OF WORK

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

1.2 DESIGN INTENT

1.3 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 0548	Vibration and Seismic Controls for HVAC
23 0549	HVAC and Electrical Installation Coordination
23 0593	Testing, Adjusting and Balancing of Mechanical Systems
23 0700	Mechanical Systems Insulation
23 3000	Air Tempering System and Equipment
23 8113	Variable Refrigerant Flow (VRF) Refrigerant Piping
23 8126	VRF Heat Pump With Heat Recovery

1.4 DEFINITIONS

- A. General: Terms will have meanings as defined in Webster's Eleventh New Collegiate Dictionary except as noted below.
- B. Entities
 - 1. Owner: New Mexico Education Retirement Board
 - 2. Architect: Dekker/Perich/Sabatini.
 - 3. Engineer: Bridgers & Paxton

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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

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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.

1.5 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 Santa Fe, 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

1.6 PRIOR APPROVAL

- A. Refer to Division 1 for Prior Approval Requirements.
- B. Equipment manufacturers and service providers are listed within the specifications for the work specified in this division. For the items listed below, the specified manufacturers and providers are the only ones presently approved, and may be the only ones allowed:
 - Air Conditioning Units
 - Pumps
 - Boilers
 - Facility Management System
- C. 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.
- D. 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.
- E. 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.
- F. Prior approval (approval prior to bid) of alternate mechanical equipment suppliers and service providers is not required. Please do not request prior approval. Alternate manufacturers and 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.

1.7 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.

1.8 SUBMITTALS

- A. See Division 1 and individual specification sections within this division for additional submittal requirements.
- B. Prior to purchasing materials, equipment and services, submit descriptive literature for review.
- C. See Division 1 and individual specification sections within this division for additional submission requirements. The following describes general submittal procedures. More specific procedures will be established after award. Whenever electronic files are to be submitted, e-mail them through normal channels. But if files are too large to e-mail, then submit them in quantities as described below.
 - 1. Submittal Schedule: Along with the first item submitted for review, include a schedule listing all items to be submitted and an approximate date for each submittal. Submit this schedule in both hard copy and electronic form (Microsoft Excel). Normal review time will be 10 working days or as indicated in Division 1. Schedule should identify any submittals for which expedited review is requested. Update this schedule and resubmit it monthly (by e-mail) for information.
 - 2. Include the following information with each submittal:
 - a. Cover sheet identifying the project name, contractor, architect, engineer, and items included. Indicate symbol numbers, spec section, etc.
 - b. A blank space large enough to accept a review stamp.
 - c. Performance under the specified conditions
 - d. Cover sheet shall clearly identify and **HIGHLIGHT** any ways in which the submitted materials, equipment or services deviate from the Specifications.
 - 3. Quantities:
 - a. Brochures: Submit no more than seven copies plus a PDF.
 - b. Drawings: Submit one reproducible, one print, plus a PDF.
 - 4. Engineer will review one original submittal and one resubmittal for each item. If the Contractor fails to provide the required data or acceptable items with his second submittal, he will be charged for the Engineer's costs for the third and subsequent reviews.
 - 5. Required Information: Submit information to allow the Engineer to easily determine whether the submitted components comply with the general design intent. Include relevant descriptions of materials, features, performance, quality and dimensions. Cross out all features, options and accessories which will not be provided. It is assumed that all specified, indicated and/or required features will be provided unless specifically noted otherwise.
 - 6. Where specifications require a local factory authorized service agent, submit the name, address, and contact information for this agent. Include this information also in the O&M Manual.
- D. Review of Submittals: Engineer will review submittals for general conformance with the design intent.

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

NO EXCEPTIONS TAKEN

Contractor may proceed with the work as submitted

EXCEPTIONS AS NOTED

Contractor may proceed with the work and without resubmittal provided he complies with all exceptions noted in the submittal, and so states in a letter

REVISE AND RESUBMIT

Resubmit in accordance with the indicated comments

REJECTED

Resubmit in accordance with the contract documents

RETURNED WITHOUT ACTION

This submittal has not been reviewed, and therefore the Engineer is returning it with no direction to the Contractor.

E. Substitutions:

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

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and electrical equipment requirements, to verify that equipment will properly fit within the space with adequate clearance for maintenance and replacement. Submit this drawing for review.

- F. Schedule: Submit all submittals in a timely manner consistent with the requirements for completing the work covered by this contract within the prescribed contract time. Be aware that there is risk in ordering components, fabricating work, and/or installing work prior to review. If the Contractor proceeds prior to review, and then the review comments required modifications to work which has begun or has been completed, then Contractor must comply with the review comments at no change in contract amount or schedule.
- G. Shop Drawings
1. Submit shop drawings for
 - a. Mechanical equipment rooms and other spaces housing air handling equipment, heat transfer equipment, fluid handling equipment, machinery, etc.
 - b. Complete supply, return, and exhaust ductwork systems, both exposed and concealed.
 - c. Piping for HVAC, plumbing, and fire protection systems, both exposed and concealed.
 2. Show the location and elevation of all equipment, ductwork and piping, as well as openings through slabs and walls. Include plans, elevations and sections as appropriate. Clearly show the manner in which the systems fit into the available space and relate to each other and to the building elements. Indicate required sleeves and openings in general construction elements. Indicate required clearances for operation, maintenance and replacement of operating devices and equipment. Drawings shall be of appropriate scale to facilitate coordination and understanding, but not smaller than 1/4 inch scale for floor plans and 1/4 inch scale for equipment rooms and chases.
 3. Conflicts: The engineer has endeavored to work out conflicts in areas where the design is congested, but has not tried to show all required offsets to coordinate with the building construction and building systems, particularly in less congested areas. The intent is that the Contractor coordinate the design of the piping and ductwork distribution systems with the building construction and the various building systems, particularly in less congested areas. Provide experienced designers to perform such services and prepare shop drawings. Exercise good design practice in working out conflicts without compromising system operation or maintenance. Provide fittings, offsets, etc., as required. Contractor shall include this design effort and include the labor and materials for such fittings and offsets in his base bid. Except in extremely unusual circumstances, no additional costs will be allowed related to working out conflicts. Coordinate with other disciplines as required. Identify on the shop drawings those areas where redesign was necessary to resolve design conflicts.
 - a. In the event that the Contractor desires direction in resolving a design conflict or desires prior approval of a recommended approach to resolving a conflict, submit an RFI which identifies the conflict and suggests a recommended solution.
 - b. In resolving conflicts, gravity lines and larger distribution mains will generally have priority over pressurized lines and smaller lines as follows:

Plumbing waste and vent lines

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Roof drains
Steam and condensate piping
Supply, return and exhaust ductwork
Fire sprinkler mains
Heating hot water and chilled water piping
Domestic hot and cold water
Fire sprinkler branch piping and sprinkler runouts
Pneumatic control piping
Miscellaneous special piping systems

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

H. Submittals Required under this Specification Section:

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

1.9 DOCUMENTED COORDINATION EFFORT

- A. After shop drawings are reviewed, incorporate any review comments and then participate in a formal and documented coordination effort with the contractors and subcontractors for other divisions of the work. Show all piping systems and equipment on the ductwork drawings, and send electronic CADD files to the General Contractor and the subcontractors for plumbing, fire protection, electrical, and other disciplines. The other subcontractors will then add their work to the CADD files.
- B. Make full-size plots of the drawings. Participate in meetings with the GC and other subcontractors to review each area, identify conflicts, and resolve conflicts. Submit the resolutions to the Engineer for review. Maintain adequate space for operation, maintenance, and code-required clearances. Ensure that all subcontractors initial each plan to indicate that they have participated in the coordination effort.

1.10 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.

1.11 GUARANTEE-WARRANTY

- A. See Division 1 for additional information on warranties. Warranties shall run for one year from substantial completion unless indicated otherwise.
- B. The following warranty shall be binding:

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

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

PART 2 PRODUCTS

2.1 PRODUCT GENERAL REQUIREMENTS

- A. General: Products supplied under Division 23 shall comply with the following except as noted elsewhere.
- B. Products shall be new; shall be the product of manufacturers regularly engaged in the production of plumbing, heating, ventilating, air conditioning, and control system equipment; and shall be the manufacturer's latest design. Specs and equipment schedules establish expectations regarding standard of quality and operating intent.
- C. Hazardous or Environmentally Damaging Materials: Products shall not contain asbestos, mercury, PCBs, or other materials harmful to people or the environment.
- D. Products shall be suitable for the conditions under which they are installed and operated. Prior to or during the submittal phase advise the Owner's representative and the Engineer in writing regarding any concerns about the suitability of the specified products for the intended application or service. Request clarification if any question exists regarding the design intent.
- E. Performance Ratings: Unless otherwise noted, all scheduled equipment performance is based on an elevation of 5500 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.

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- 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

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secondary overcurrent protection. Provide terminal strips for field-installed control wiring. Provide unit-mounted, unit-specific wiring diagrams on durable paper, attached to inside of control panel door or otherwise affixed to the unit. All electrical components shall be UL Listed or Recognized. All factory-installed electrical work shall comply with the NEC unless the overall unit is listed by an organization acceptable to the AHJ, and listed to a standard acceptable to the AHJ.

1. Where equipment includes an LCD or other, similar display for operator interface, display all information in English. Displays should be readily understandable and should not require the user to look up display codes in a reference manual.
2. Provide battery backup to retain all memory and programming, and to keep all clock-related functions powered through a 1-week power outage.
3. Controls interface with the FMS:
 - a. Digital Inputs to FMS: 24V DC sourced from equipment.
 - b. Digital Outputs from FMS: Equipment to have form C relays, max 250V DC, 2 A.
 - c. Analog Inputs to FMS: 4-20 mA, 0-5V DC, or 0-10V DC sourced from equipment.
 - d. Analog Outputs from FMS: 4-20 mA sourced from FMS.

2.2 ELECTRICAL COMPONENTS

- A. General: Except as noted, all electrical products and equipment shall comply with the requirements of this section, whether field installed or factory installed. See “Product General Requirements” and “Installation General Requirements” in Parts 2 & 3 of this spec section for additional requirements.
- B. Motors
 1. General: Except as noted motors shall be horizontal, open drip-proof, 4-pole, 1750 RPM, rated per NEMA MG-1, with fabricated steel or cast iron casing, motor terminal box adequately sized for conductors one-size larger than specified, SS nameplate per NEMA MG-1-20.60, connection diagram attached to motor, compression lugs for power feeds and ground conductor, grease lubricated sealed ball bearings or roller bearings with standard grease fitting zerk and relief tapping, factory lubricated, dynamically balanced to no more than 50% of the NEMA allowable vibration limits. For motors powering V-belt drives, provide a cast iron or steel base with slide rail and adjustable belt tension device. Install motors and equipment on foundations and align as required. 40 deg C rise and total temperature rise of 65 deg C ambient.
 - a. 3/4 hp and smaller: 115V, single phase, 60 Hz, split phase or permanent split capacitor (PSC), NEMA Type N or O, with built-in thermal overload protection.
 - 1) Multi-speed motors.
 - b. 1 hp and greater: 208 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.

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- 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:

HP	Open Drip-Proof (ODP)			Totally Enclosed Fan-Cooled (TEFC)		
	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.

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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.

D. Variable Speed Drives

1. General: Factory fabricated, variable voltage and frequency type for driving the specified AC motor in a typical HVAC variable torque application, listed per UL-508, and rated for installation within a return air plenum. Performance specified here is based on driving a 4-pole NEMA B induction motor. Select and size VFDs so they are compatible to drive motors with characteristics as indicated on the drawings.
2. Conditions of Service: Suitable for installation and operation at 0 – 100% speed and load throughout the following conditions:
 - a. Electric Service: Indicated voltage +10% or -30%, voltage imbalance +/-3%, 48-63 Hz.
 - b. Ambient Temp & Humidity: 32-104°F and 0-95% RH non-condensing. Derate capacity 1% per 1.8F° above 104°F.
 - c. Elevation: As specified in Section 23 0500. Derate capacity 2% per 1000 ft above 3300 Ft elevation.
 - d. Output Cable: Up to 328 ft length or additional length if indicated on drawings.
 - e. Vibration: Rated per IEC 68-2-34/35/36.
 - f. Seismic: Certified and labeled to IBC 2015.
3. Enclosure: NEMA-rated and suitable for mounting on a wall or Unistrut stand; zero clearance to obstructions on the sides and back; and conduit connection on top, bottom, back or sides (field selectable).
4. Power Side: All required power components including 3-phase rectifier bridge, DC capacitor bank, and output IGBT. Manual bypass starter (if indicated in schedule): Electro-mechanical or electronic, 3-contact type, but with provisions to power VFD controls troubleshooting while operating on bypass starter.
5. Controls: All required safety and operating controls, control transformer with secondary overload protection, removable and hot pluggable local control panel with LCD display. Fully programmable from the LCD display without the use of any additional devices.

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LCD shall be bright, easy to read, English language, engineering or SI units (set it up to display in engineering units), not utilizing codes or lookup tables. Provide the following functionality:

- a. Automatic load-dependent carrier frequency control to optimize motor-drive efficiency, maximize motor life, and minimize motor heating. Automatically optimize between low speed switching (for reliable starts and smooth low speed operation) and high speed switching (to maximize drive efficiency).
 - b. Power failure auto restart.
 - c. Flying start to automatically synchronize power-up after voltage trip.
 - d. Drive over-temperature protection with automatic carrier frequency adjustment and automatic derate prior to tripping.
 - e. 3-phase output current sensing.
 - f. 1-3600 second manually adjustable acceleration and deceleration ramps with automatic override to prevent overload.
 - g. Temperature-controlled VFD cooling fans.
 - h. PID controller.
 - i. Minimum three lockout frequencies.
 - j. Trickle current feature to allow current flow to prevent condensation when a motor is shut down.
 - k. Controls to prevent damage in the event that an input or output disconnect is opened while VFD is powering motor.
 - l. No load/broken belt warning.
 - m. Separate warnings for high frequency, low frequency, high current, low current.
 - n. Hold last state if analog control signal, RS-485 communication, or keypad control signal is lost.
 - o. Provisions for up to 4 digital inputs to trip the VFD, with programmable English-language display message on LCD (e.g., "Vibration Switch," "Smoke Detector," "Duct High Pressure," etc).
 - p. Fault log storing the most recent ten faults with error code, time and value.
6. Protection: Motor thermal overload; short circuit, ground fault, heat sink high temperature cutout, high or low voltage on DC bus, loss of phase, motor-generated over-voltage, phase reversal.
7. Output
- a. Voltage: 0 – 100% of motor rated voltage at any input voltage within the range given above.
 - b. Frequency: 0 – 120% of input frequency.
 - c. Minimum 96% efficiency at rated frequency and full load, and 80% efficiency at 50% speed.
 - d. Minimum 98% power factor at all speeds and loads.
 - e. Torque: Capable of the following torque output as a percentage on rated full speed

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torque: Breakaway: 160% for 0.5 seconds; Acceleration: 100%; Overload: 110%.

- f. Audible Sound: Not to exceed the following dBA sound pressure when measured one meter from the VFD under any operating condition:

VFD

<u>Hp</u>	<u>NEMA-1</u>	<u>NEMA3R/12</u>
1 – 10	50	62
15 – 60	61	66
75 – 300	70	65

- g. Harmonic Distortion Analysis: Supplier or manufacturer must have the capability to perform a computerized analysis of the electrical distribution system to determine the harmonic distortion generated by the VFDs. If such an analysis is requested, a change order will be issued to cover the associated costs. The Engineer will provide a CD of the electrical CADD files, and will define the harmonic distortion criteria to be met. Analyze different input line reactors or other approaches to address harmonic distortion, and recommend the most appropriate approach to meet these criteria.
8. Interface with the project's FMS (hard-wired, may be individual points or may be through the RS-485 communication port:
- a. DIs: Start/stop (24VDC sourced from VFD).
 - b. DOs: Status, Common Alarm (Form C Relays, max 250VAC 2A).
 - c. AIs: Control signal (4-20 mA, 0-5 VDC, or 0-10 VDC).
 - d. AOs: Output speed (%), output current (%) (4-20 mA).
9. Safeties: Minimum two sets of terminals that can be wired to external safeties. When safety is energized VFD shall display a programmable alarm message (e.g., "Vibration Switch," "Fire Alarm", "High Static Pressure."
10. Startup: Provide startup by a factory-trained technician. Provide as many site visits as required to properly start VFDs and driven equipment. Coordinate with the controls contractor regarding proper interface with the FMS. Coordinate with the suppliers of the driven equipment, and program all lockout frequencies into the drive. Submit a startup report for each VFD. Where multiple VFDs are provided and for projects with phased construction, multiple site visits will be required. Instruct the Owner's operating personnel regarding VFD programming and operation.
11. Approved Manufacturers: Danfoss VLT 6000, ABB, Yaskawa, OAE.

2.3 ELECTRICAL WIRING AND CONTROL EQUIPMENT

- A. Provide wiring and conduit as scheduled in Section 23 0549.
- B. Coordinate with all disciplines to ensure that all necessary components of control work are included and fully understood.

2.4 IDENTIFICATION

- A. Scope: Identify all equipment, ductwork, valves, piping, and control devices shown on the Drawings, identified in the equipment schedules, and indicated in these Specifications. Provide submittals for products and procedures used for identification.
- B. Equipment: For all mechanical equipment supplied or installed under Division 23, provide an equipment identification tag or stencil unit number onto the equipment. Stencils shall be minimum 3-inch height, dark contrasting color, of a material suitable for the application.
 - 1. For rooftop HVAC equipment, provide a permanently affixed, weather-resistant label to identify the areas served.
- C. Valves: Provide each valve with a stamped metal tag secured to the valve. Tag shall indicate the valve number, service and function. Provide two sets of prints of drawings showing floor plan for each floor with all valves accurately located and labeled. Drawings shall be neat and easily readable. Provide a typed valve chart, listing the valve number, size, location, function, normal operating position, for each valve. List valves by system, i.e., domestic cold water, hot water, chilled water, etc. Tags shall be stamped brass 1-1/2" diameter, and secured to valves by heavy copper figure eight hooks, braided stainless steel wire anchor, or other approved means.
- D. Ductwork: Identify ductwork at or near the fan with stenciled signs on insulated ductwork or engraved laminated plastic signs secured by rustproof screws on un-insulated ductwork. Sign shall identify air conditioning system or fan unit and area served.
- E. Piping
 - 1. Provide color-coded pipe labels indicating the service of the pipe and the direction of flow. Piping labels shall comply with ANSI Standard A13.1 regarding color coding and size of lettering. The following standardized color code scheme shall be used:
 - a. Yellow - Hazardous Materials.
 - b. Green - Liquid Materials of Inherently Low Hazard.
 - c. Blue - Gaseous Materials of Inherently Low Hazard.
 - d. Red - Fire Protection Materials.
 - 2. Labels shall be semi-rigid plastic identification markers. Labels shall "span-on" around pipe without the requirement for adhesive or bonding of piping sizes 3/4 inch through 5 inches. Labels for piping 6 inches and larger shall be furnished with [spring attachment](#) at each end of label. "SETMARK" Type SNA, 3/4 inch through 5 inch size and Type STR, 6 inches and larger, as manufactured by Seton Name Plate Corporation, Brady, or equivalent.
 - 3. For retrofit projects the system names shall match existing.
 - 4. 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.
 - 5. Provide the following labels, with ANSI/OSHA color and banding for all piping systems as shown on the Drawings and as listed below:

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<u>Service/Legend</u>	<u>Letter</u> <u>Color</u>	<u>Background</u> <u>Color</u>	<u>Tape Banding</u> <u>Color</u>
Domestic Cold Water	White	Green	2" Green
Domestic Hot Water	Black	Yellow	2" Yellow
Domestic Hot Water Return	Black	Yellow	2" Yellow
Soft Cold Water	White	Green	2" Green
Soft Hot Water	Black	Yellow	2" Yellow
Industrial Cold Water	White	Green	2" Green
Fire Protection Water	White	Red	2" Red
Fire Auto Sprinkler	White	Red	2" Red
Fire Dry Standpipe	White	Red	2" Red
Fire Wet Standpipe	White	Red	2" Red
Fire Comb. Standpipe	White	Red	2" Red
Compressed Air	White	Blue	2" Blue
Roof Drain	White	Green	2" Green
Sanitary Sewer	White	Green	2" Green
Storm Sewer	White	Green	2" Green
Natural Gas	Black	Yellow	2" Black
Steam, PSIG	Black	Yellow	2" Black
Condensate Return, Gravity	Black	Yellow	2" Black
Condensate Return, Pumped	Black	Yellow	2" Black
Boiler Feed Water	Black	Yellow	2" Black
Chilled Water Supply	White	Green	2" Green
Chilled Water Return	White	Green	2" Green
Heating Water Supply	Black	Yellow	2" Yellow
Heating Water Return	Black	Yellow	2" Yellow
Condensing Water Supply	White	Green	2" Green
Condensing Water Return	White	Green	2" Green

6. 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.

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- e. Adjacent to all special fittings (regulating valves, etc.) in piping systems.
 - f. At every access door.
7. Underground Piping: Provide a continuous, preprinted, bright colored, plastic ribbon cable marker with each underground pipe regardless of whether encased. Locate directly over buried pipe, 6 inches to 8 inches below finished grade. Marker tape used in conjunction with buried plastic piping systems shall be special detector type.
- F. Control System Devices: All automatic controls, control panels, zone valves, pressure electric, electric pressure switches, relays and starters shall be clearly tagged and identified. Wording shall be identical to that on the control diagram in the Contract Drawings.

2.5 GENERAL CONSTRUCTION COMPONENTS

- A. Roof Curbs and Equipment Support Rails
- 1. General: Factory fabricated, minimum 12-inch high, galvanized steel, configured to account for roof pitch where pitch exceeds 1/4-inch/ft or where required by manufacturer of supported equipment. Coordinate with roofer and provide cant and step if needed to match roof construction. Actual curb heights to be coordinated by contractor with roofing insulation height to maintain code-required height above final roofing elevation.
 - 2. Roof Curbs: 1.5-inch fiberglass insulation with nominal 2" x 2" wood nailer. Provide damper tray where a damper is indicated. Thycurb TC, Greenheck, RPS, OAE.
 - 3. Equipment Support Rails: Nominal 2" x 4" wood nailer. Thycurb TEMS, Greenheck, RPS, OAE.
- B. Access Doors (ADs)
- 1. Steel frame and door, surface mounted, factory primed, 150° opening, flush, screw-driver operated cam lock, minimum 24" x 24" except as approved, but larger where required for proper access. Where ADs are installed in general construction with a pattern, match AD dimensions to this pattern. Milcor, Krueger, OAE.
 - a. Sheet Rock Wall or Ceiling: With drywall bead on frame, Milcor Style DW.
 - b. Plaster Wall or Ceiling: Milcor Style K.
 - c. Masonry Walls: Milcor Style M.
 - d. 1-hr and 2-hr rated walls: UL Listed for 1.5-hr Class B Fire Rating, self-closing and self-latching. Milcor Style UFR.
 - e. Suspended Ceilings: Milcor Style AT.
 - f. Fire Rated Suspended Ceilings: Milcor Style ATR.
- C. Painting: Finish painting of mechanical systems and equipment will be under Spec Section 09 9100, "Painting," unless equipment is specified to be provided with factory-applied finish.

2.6 MISCELLANEOUS PROVISIONS

- A. Flow Diagrams: Provide half-size prints of each system flow diagram, including air handling, steam, chilled water, heating water, domestic water, domestic HW, etc. Mount framed under plexiglass, and locate either on the associated AHU or on a nearby wall. Incorporate any as-built revisions.

PART 3 EXECUTION

3.1 INSTALLATION GENERAL REQUIREMENTS

- A. Cooperation with Other Trades: Refer to other parts of these Specifications covering the work of other trades which must be carried on in conjunction with the mechanical work so that the construction operations can proceed without harm to the Owner from interference, delay, or absence of coordination. Be responsible for the size and location of all openings, foundations, etc.
- B. Trenching and Backfilling: Provide all excavation, trenching and backfilling required for the installation of the work of this division.
- C. Manufacturer's Instructions: Install all products in accordance with manufacturers' recommendations and the requirements of any applicable listings. If manufacturers' recommendations and/or requirements of applicable listings conflict with plans and specifications, report such conflicts to the Owner's Representative.
- D. Field Measurements: Verify all dimensions and conditions governing the work. Examine adjoining work on which the work of this Division is dependent, and report any deficiencies.
- E. Do not compromise the building structural, fire resistant construction or vapor barrier system.
- F. Supports for Equipment and Systems: Foundations and structural supports for equipment will generally be provided by others. The contractor for this division shall provide supplementary supports as required to support equipment, distribution systems, and other components installed under this division. Prior to installing mechanical work, examine foundations and supports to ensure they are adequate to properly support the equipment. Provide all necessary foundations, structures, supports, inserts, sleeves, etc, for installation of mechanical and plumbing equipment, ductwork and piping, etc. Coordinate installation of such devices with all disciplines. Verify that the devices and supports are adequate as intended and do not overload the building structure.
- G. Concealed or Buried Work: For work which is underground or which will be concealed by building construction, provide digital photographs to document the installation throughout the construction project, but not less than weekly. Include plans indicating where the photographs were taken. Notify the OR of when the work will be complete and provide OR a minimum five-day period to inspect the work after completion but prior to when it is backfilled or concealed by building construction.

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- H. Access Doors: Provide as required for access to valves, dampers, controls, or other items for which access is required for either operation or servicing. The type of access door shall be as required by the room finish schedule.
- I. 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.
- M. Systems Commissioning: A commissioning Agent will participate in the construction phase of the project.

3.2 DRAWINGS

- A. The drawings show the general arrangement of the piping, ductwork, equipment, etc. Follow them as closely as actual building construction and work of other trades will permit. Where discrepancies occur between Plans and Specifications, the more stringent shall govern. All Contract Documents shall be considered as part of the work. Because of the small scale of the drawings, it is not possible to indicate all offsets, fittings and accessories, which may be required, and no attempt has been made to do so. Rather, the drawings convey the general design intent. Investigate the structural and finish conditions affecting the work and arrange the work accordingly, providing fittings, valves, and accessories as required to meet such conditions. Show any such changes on the Record Drawings.

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- B. Should any doubt or question arise in respect to the true meaning of the drawings or specifications, submit an RFI.
- C. Install equipment, piping, ductwork, and electrical systems with proper clearance for operation, service, and maintenance, including minimum clearances required by applicable codes, manufacturer's installation instructions, etc. Include proper clearance in front of and above electrical equipment as defined by the National Electric Code (NEC). Piping and ductwork systems shall not be routed through or above electrical equipment rooms, telecommunications rooms, elevator machine rooms, or electrical equipment spaces within mechanical equipment rooms.
- D. Arrange all concealed mechanical systems carefully to fit within the available space without interference with adjacent structural and electrical systems. Make all necessary provisions for penetrations of piping and ductwork, including sleeves and blockouts in structural systems. The exact location of all exposed mechanical systems, including grilles, registers, and diffusers; access doors; sprinkler heads; piping and ductwork exposed within finished areas; and other equipment and devices as applicable, shall be coordinated with the Architect, who shall have final authority for the acceptance of the work as it relates to the aesthetic design for the facility.

3.3 CONCRETE BASES AND HOUSEKEEPING PADS

- A. Concrete bases and housekeeping pads shall be installed under all pieces of mechanical equipment unless specifically deleted by the Specifications or Drawings.
- B. Be responsible for the accurate dimensions of all pads and bases and furnish and install all vibration isolators, anchor bolts, etc.
- C. Provide concrete housekeeping pad foundations for all floor mounted equipment installed under this section unless otherwise shown on the Drawings. All concrete bases and housekeeping pads shall conform to the requirements specified under Division 3, Concrete, portions of these Specifications. Pad foundations shall be 4 inches high minimum, unless otherwise indicated on the Drawings. Chamfer edges shall be 1 inch. Faces shall be free of voids and rubbed smooth with carborundum block after stripping forms. Tops shall be level. Provide dowel rods in floor for lateral stability and anchorage.
- D. Equipment anchor bolts shall be set in a galvanized pipe or sheet metal sleeves 1 inch larger than bolt diameter. Anchor bolts shall be high strength steel J-shape. Anchor bolt design shall be arranged and paid for by the Contractor.
- E. Machinery bases, bed plates, sole plates, or vibration isolation units shall be carefully aligned, shimmed, leveled, and then grouted in place with commercial non-shrink grout. When a flexible coupling is employed as a part of the drive train, the coupling shall be aligned before the machinery base is grouted.

3.4 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

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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 0548 for requirements for seismic supporting of mechanical equipment and systems.

3.5 PRESSURE RELIEF DEVICES

- A. Refrigerant pressure relief devices and fusible plugs shall be installed with piping to a safe location in accordance with ANSI/ASHRAE Standard 15. Discharge shall be to atmosphere at a location not less than 15 feet above the adjoining ground level and not less than 20 feet from any window, ventilation opening, or exit from any building. Discharge line sizing shall conform to ANSI/ASHRAE Standard 15-1994.
- B. Each discharge pipe shall be equipped with a drip leg capable of holding 1 gallon of liquid. The drip leg shall include a manual drain valve.

3.6 INSTALLATION CHECK

- A. An experienced, competent, and authorized representative of the equipment listed below shall visit the site of the work and inspect, check, adjust if necessary, and approve the installation for the equipment listed below. The equipment supplier's representative shall revisit the job site as often as necessary until all trouble is corrected and the equipment installation and operation is approved and accepted.
- B. Each equipment supplier's representative shall furnish a written report certifying that the equipment (1) has been properly installed and lubricated; (2) is in accurate alignment; (3) is free from any undue stress imposed by connecting piping or anchor bolts; and, (4) has been operated under full load conditions and that it has operated satisfactorily.
- C. Equipment requiring installation check includes the following:
 - Water Softener
 - Domestic Hot Water Heaters

3.7 OPERATION PRIOR TO ACCEPTANCE

- A. Operation of equipment and systems for the benefit of the Owner prior to substantial completion will be allowed provided that a written agreement between the Owner and the Contractor has established warranty and other responsibilities to the satisfaction of both parties.
- B. Operation of equipment and systems for the benefit of the Contractor, except for the purposes of testing and balancing, will not be permitted without a written agreement between the Owner and the Contractor establishing warranty and other responsibilities.

3.8 OPERATION AND MAINTENANCE (O&M) INSTRUCTIONS

- A. At completion of the project provide two complete bound sets of the following documents, along with two CDs containing searchable PDFs of these documents. Organize bound information in a logical fashion with a table of contents and tabs for the different sections. Organize PDFs in a logical fashion with bookmarks to assist the operating personnel in retrieving desired data. Provide minimum two 1-hour sessions to instruct Owner's facility personnel in how to find information in the bound O&Ms and the PDFs. Take attendance and submit the attendance list to the Owner's Representative. Include the following:
1. Approved Submittals.
 2. Test reports.
 3. O&M manuals and instructions covering all equipment supplied under this Division, with all non-applicable information crossed out. Clearly identify all required routine maintenance. Include parts lists.
 4. A master Lubrication Chart listing each piece of equipment, the recommended oil or grease, and the recommended frequency of lubrication.
 5. The names and addresses of at least one service agency capable of providing required maintenance for each item of equipment supplied.
 6. Complete temperature control diagrams including control descriptions, system sequence of operation, operating instructions, control system maintenance and calibration information, wiring diagrams, and all control setpoints. See Section 23 0900 for additional requirements.
- B. See Division 1 for additional requirements concerning manuals, manual distribution, and maintenance materials.
- C. Submit O&M manuals for review and distribution to the Owner not less than two weeks prior to the date scheduled for O&M instructions as specified.
- D. Demonstrate proper system operation to the owner's operating staff. Provide the services of the contractor and subcontractors (e.g., mechanical, T&B, temperature control, etc), as required to properly demonstrate system operation.
- E. Provide the necessary skilled labor and helpers to operate the mechanical systems and equipment for a period of 7 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.

3.9 RECORD DRAWINGS

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

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- B. Maintain a full-size set of marked-up prints showing the installed location and arrangement of all work under this division, and in particular where changes were made during construction. Keep record drawings accurate and up-to-date throughout the construction period. Owner's Agents may request to review record drawings during construction and in conjunction with review and approval of monthly pay requests. Include copies of all addenda, RFIs, bulletins, and change orders neatly taped or attached to record drawing set. At the completion of the project send the Engineer full-size plans clearly showing all changes from the original design marked up in red so as to facilitate the Engineer incorporating these changes into the Engineer's CADD files. Forward record drawings to the Owner's Representative prior to submitting a request for substantial completion.

3.10 SITE VISITS AND OBSERVATION OF CONSTRUCTION

- A. The Engineer may make periodic visits to the project site at various stages of construction in order to observe the progress and quality of various aspects of the work so as to determine if such work is proceeding in general accordance with the Contract Documents. This observation will not release the Contractor from his responsibility to supervise, direct, and control all construction work and activities. The Engineer has no authority over, or responsibility for means, methods, techniques, sequences, or procedures of construction or for safety precautions and programs, or for failure of the Contractor to comply with applicable laws, regulations, or codes.
- B. Prior to substantial completion, request that the Engineer provide a final observation visit. Complete the attached "Final Observation Checklist," and include it with this request. For any items that are not applicable, mark them "N/A."

3.11 PROJECT CLOSEOUT

- A. Submit written certification that all work complies with the specifications and applicable codes. Submit certifications and acceptance certificates including proof of delivery of record drawings, O&M manuals, spare parts required, and equipment warranties.

END OF SECTION

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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.

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- _____ 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 |

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_____ 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.

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- _____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.

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_____ 9. Refrigerant sensors and equipment room shutdown have been tested.

GENERAL ITEMS

The following specified items have been submitted:

_____ 1. Record Drawings (to be submitted prior to final payment to the Contractor).

_____ 2. Operation and maintenance manuals.

_____ 3. Manufacturer's representative installation check and certification submitted (see list of equipment, Section 23 0500).

_____ 4. Testing and balancing reports.

_____ 5. Test kits furnished to Owner.

_____ Flow Measuring Devices

_____ Flow Balance Valves

_____ Flow Control Devices

_____ 6. Temperature control schematics and sequence of operation.

_____ 7. Wall-mounted lubrication, valve, and temperature control charts have been installed.

DIVISION 23 SUBSTITUTION REQUEST FORM (SRF)

TO: BRIDGERS & PAXTON CONSULTING ENGINEERS

PROJECT: _____

We hereby submit for your consideration the following product instead of the specified item for the above project:

Section: _____ Page: _____ Paragraph/Line: _____ Specified Item: _____

Proposed Substitution: _____

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

1. Will changes be required to building design in order to properly install proposed substitutions? YES NO

If YES, explain: _____

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

3. List differences between proposed substitutions and specified item.

Specified Item	Proposed Substitution
_____	_____
_____	_____

4. Does substitution affect Drawing dimensions? YES NO

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

6. Does the manufacturer's warranty for proposed substitution differ from that specified? YES NO

If YES, explain: _____

7. Will substitution affect progress schedule? YES NO

If YES, explain: _____

8. Will maintenance and service parts be locally available for substitution? YES NO

If YES, explain: _____

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

SUBMITTED BY: Firm: _____ Date: _____

Address: _____

Signature: _____ Telephone: _____

For Engineer's Use Only

Accepted _____	Not Accepted _____	Received Too Late _____
By: _____	Date: _____	
Remarks: _____		

LICENSE AGREEMENT FOR CADD DATABASE OR BIM MODEL

PROJECT: _____

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

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

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

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

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

CONTRACTOR'S REPRESENTATIVE

Signature: _____ Company Name: _____

Name: _____ Address 1: _____

Title: _____ Address 2: _____

Date: _____

SECTION 23 0503 TRENCHING AND BACKFILLING

PART 1 GENERAL

1.1 REQUIREMENTS

- A. Conform to 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.

PART 2 PRODUCTS

Not Applicable.

PART 3 EXECUTION

3.1 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. Sheet piling 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

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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.

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- L. The Contractor shall protect from damage all existing underground utilities indicated on the Contract Drawings or field located by an underground utility locator service by the Owner prior to excavation operations. Any damage to such existing utilities shall be repaired by the Contractor without additional costs to the Owner.
- M. Provide density test for trench, backfill in accordance with Division 33 requirements.

END OF SECTION

SECTION 23 0504 PIPE AND PIPE FITTINGS

PART 1 GENERAL

1.1 REQUIREMENTS

- A. Conform with applicable provisions of the General Conditions, Supplemental General Conditions and General Requirements.
- B. Lead Ban: All systems and system components, pipe, fittings, and fixtures 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.

PART 2 PRODUCTS

2.1 PIPE AND PIPE FITTINGS

- A. Piping system materials shall be furnished as specified under the Sections describing the various piping systems. Pipe fittings shall be compatible with the piping systems in which they are installed.
- 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° 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

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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.

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- J. Fittings for special piping systems including acid resistant waste and vent systems, high purity water distribution systems, PVC piping systems, shall be compatible with the piping system requirements and shall be as specified in Division 22.

2.2 FLOOR, WALL AND CEILING PLATES

- A. Where uncovered, exposed pipes pass through finished floors, finished walls, or finished ceilings, they shall be fitted with chromium plated spun brass escutcheon plates. Plates shall be large enough to completely close the hole around the pipe, and shall be not less than 1-1/2" or more than 2-1/2" larger than the diameter of the pipes. All plates shall be securely held in place.

2.3 UNIONS

- A. Piping 2-1/2" and larger shall be provided with bolted flange union connections. Weld flanges and bolting shall conform to ANSI B16.5. Bronze flanges shall conform to ANSI B16.24. Flange class shall be as specified in the applicable Sections of the Specifications.
- B. Malleable iron grooved joint unions with brass to iron seats, Class 125, 250, or 300, as required by the application and compatibility requirements with the piping system fitting classification, conforming to MSS SP-77 and ANSI B16.39, shall be provided in piping systems 2" and smaller. Copper unions conforming to ANSI B16.22 shall be provided in copper piping systems. Union connections shall be installed at all coils, control valves, equipment connections, and at other locations shown on the drawings, and required for proper system operation and maintenance.

2.4 DIELECTRIC FITTINGS

- A. Dielectric insulating fittings shall be provided to connect dissimilar metals, such as copper tubing to ferrous metal pipe. Connections 2" and smaller shall be threaded dielectric union conforming to ANSI B16.39. Connections 2-1/2" and larger shall be flange union with dielectric gasket and bolt sleeves, conforming to ANSI B16.42. Insulating fittings will not be required between bronze valves and copper piping, unless otherwise specified.

2.5 PIPE HANGERS AND SUPPORTS

- A. All piping shall be rigidly supported from the building structure by means of hanger assemblies properly selected and sized for the application in accordance with the manufacturer's recommendations and specifications. Pipe hangers shall be Grinnell, B-Line, 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.

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- 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

<u>Steel Piping</u>	<u>- Maximum Spacing</u>
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"
14" and larger	- [16'-0"] [12'-0"]
<u>Copper Piping</u>	<u>- Maximum Spacing</u>
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

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- 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)

Size	PVC AND CPVC				CPVC			
	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)

Size	PVC AND CPVC				CPVC			
	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	--	--	--

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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:	<u>1.0</u>	<u>1.1</u>	<u>1.2</u>	<u>1.4</u>	<u>1.6</u>	<u>2.0</u>	<u>2.5</u>
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 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.

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- K. 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.
- L. The use of pipe hooks, chains, or perforated iron for pipe hanger supports will not be permitted.
- M. All insulated piping systems specified in Section 22 0700, Plumbing Insulation and Section 23 0700, HVAC Insulation, shall be provided with individual hangers sized to encircle the insulation. See applicable sections for insulation thickness requirements. The specified piping systems where supported by means of trapeze hangers shall not rest directly on the trapeze horizontal members. The insulation at hangers and trapeze hangers shall be protected by means of insulation shield, Grinnell Fig. 167, 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.
- N. 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.

2.6 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.

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- 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.

2.7 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.

PART 3 EXECUTION

3.1 PIPING INSTALLATION

- A. Provide and erect, according to the best practices of the trade, all piping shown on drawings and required for the complete installation of these systems. The piping shown on the drawings shall be considered as diagrammatic for clearness in indicating the general run and connections, and may or may not in all parts be shown in its true position. The piping may have to be offset, lowered or raised as required or as directed at the site. This does not relieve the Contractor from responsibility for the proper erection of systems or piping in every respect suitable for the work intended as described in the specifications. In the erection of all piping, it shall be properly supported and proper provisions shall be made for expansion, contraction and anchoring of piping. All piping shall be cut accurately for fabrication to measurements established at the construction site. Pipe shall be worked into place without springing and/or forcing, properly clearing all windows, doors, and other openings and equipment. Cutting or other weakening of the building structure to facilitate installation will not be permitted. All pipes shall have burrs and/or cutting slag removed by reaming or other cleaning methods. All changes in direction shall be made with fittings. All open ends of pipes and equipment shall be properly capped or plugged to keep dirt and other foreign materials out of the system. Plugs of rags, wool, cotton waste or similar materials may not be used in plugging. All piping shall be arranged so as not to interfere with removal and maintenance of equipment or filters or devices; and so as not to block access to manholes, access openings, etc. Flanges or unions as applicable for the type of piping specified shall be provided in the piping at connections to all items of equipment including refrigeration machines. All piping shall be so installed to ensure noiseless circulation. All valves and specialties shall be so placed to permit easy operation and access, and all valves shall be regulated, packed and adjusted at the completion of the work before final acceptance. All piping shall be erected to ensure proper draining. Water piping may be run level but shall be free from traps.

3.2 JOINTS

- A. Caulked Joints: Caulked joints in hub-and-spigot piping and vent piping shall be packed firmly with white oakum, "Sealite No. 110," or hemp and caulked with pure molten lead not less than 1" deep. Resilient molded gasket joints or "Ty-Seal" may be used in lieu of lead and oakum for sanitary soil, waste and vent piping. No-hub pipe and fittings will be accepted with the exception that no-hub pipe and fittings shall not be allowed for buried installation.

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- B. Screwed Joints: Shall have American Taper pipe threads. Ream pipe ends and remove burrs after threading. Make up joints using Teflon tape or other approved compound applied to the male threads only.
- C. Solder Joints: Copper tubing shall be cut square and burrs removed. Both inside of fittings and outside of tubing shall be well cleaned before sweating. Care shall be taken to prevent annealing of fittings and hard drawn tubing when making connections. Joints for sweated fittings shall be made with a non-corrosive paste flux and solid 95-5 tin-antimony wire solder, unless otherwise specified. Cored solder will not be permitted. 50/50 lead solder shall not be permitted for any applications.
- D. Welded Joints: On black steel piping 2-1/2" and above in size, the joints may be welded. Welding shall be done using either gas or electric welding equipment. Certified welders shall be used. Welders shall be certified in accordance with Section IX of ASME Boiler and Pressure Vessel Code, latest edition. All pipe surfaces shall be thoroughly cleaned before welding. Each joint shall be beveled before being welded. Piping shall be securely aligned and spaced, and the width of circumferential welds shall form a gradual increase in thickness from the outside surface to the center of the weld. All fittings used in the welded piping systems shall be standard ASA fittings, and shall be of standard pipe thickness. The Contractor shall provide a fireproof mat or blanket to protect the structure and adequate fire protection at all locations where welding is done. The use of fittings formed from welded pipe sections will not be permitted.
- E. Flanged Joints: Flanged joints shall conform to the American Standard for cast iron flanged pipe fittings, Class 125, 150 or 300 as specified in the applicable Sections of these specifications. Gaskets shall be full face or ring type, non-asbestos, suitable for the service on which used.

3.3 PUMP AND EQUIPMENT CONNECTIONS

- A. All piping connecting to pumps and other equipment whether connected utilizing flexible connectors or with solid pipe connectors, shall be installed without strain at the pipe connection of the equipment. The Contractor shall be required, if so directed, to disconnect piping to demonstrate that piping has been so connected.

3.4 EXPANSION AND CONTRACTION

- A. The Contractor shall make all necessary provisions for expansion and contraction of piping with offsets or loops and anchors as required to prevent undue strain. Contractor shall provide shop drawings for proposed method and arrangement for control of expansion and contraction of piping. See Section 23 0505 for expansion joints, expansion compensators, pipe guides and pipe anchors.

3.5 PROTECTIVE COATINGS

- A. All underground steel pipe shall be wrapped with "Scotchwrap" No. 50 tape or equivalent, to give not less than two complete layers on the entire underground piping system, or piping shall have X-Tru-Coat factory applied plastic protective covering.

3.6 FLUSHING, DRAINING AND CLEANING PIPE SYSTEMS

- A. The Contractor shall flush out all water systems with water before placing them in operation. Other systems shall be cleaned by blowing them out with compressed air or nitrogen. After systems are in operation and during the test period, all strainer screens shall be removed and thoroughly cleaned.

3.7 TESTING

- A. Before any insulation is installed or before piping is covered or enclosed, all piping systems shall be tested and proven tight at not less than 150% of the maximum service pressure which the piping systems will be required to handle. Piping system tests shall be as specified in the applicable sections of this Specification. All tests shall be witnessed and approved by the Architect.
- B. All labor, material, and equipment required for testing shall be furnished by the Contractor. The Contractor shall be responsible for all repairs and retesting as required. All instruments and other equipment whose safe pressure range is below that of the test pressure shall be removed from the line or blanked off before applying the tests. To perform tests, all lines shall be flushed and cleaned.
- C. All safety measures required by codes or ordinances or reasonably applicable to the situation shall be provided by the Contractor in conjunction with the testing of the piping systems.
- D. Equipment or piping to be pressure tested shall not be insulated, covered, or concealed prior to that test. Underground piping may be partially backfilled prior to pressure test when required for application of the test except that joints shall remain exposed until after the test. Tie rods, clamps etc., shall be in place and fastened.
- E. Tests shall not be used to establish pressure ratings.
- F. Protect all piping and equipment against over pressure, collapse from vacuum, and hydraulic shock during the filling, testing and draining procedures. Seats of iron valves shall not be subjected to a pressure in excess of the maximum cold working pressure of the valve. Pressure tests against other closed valves shall not exceed twice the normal rating.
- G. Apply test pressure only after the system and test medium are at approximately the same temperature, preferably not less than 60⁰F. 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.

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- 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

SECTION 23 0505 PIPING SPECIALTIES

PART 1 GENERAL

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.

PART 2 PRODUCTS

2.1 STRAINERS

- A. Strainers suitable for the application shall be furnished and installed on the high pressure side of pressure reducing valves, pressure regulating valves, suction side of pumps, inlet of indicating and control instruments and equipment subject to sediment damage, and as shown on the drawings. Strainers shall be "Y"-type unless basket strainers are indicated. Tee-type strainers will not be accepted. Strainer element shall be removable without disconnecting piping. Screens shall be Type 304 stainless steel with 1/8 inch perforations for water service air and gas services. Every strainer shall be provided with a blow-off connection not less than 1/2" NPT and

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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° 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°F maximum temperature, Sarco 528-B-125, or equivalent.

2.2 SUCTION DIFFUSERS

- A. Suction diffusers shall be furnished and installed at the suction of pumps where indicated on the drawings. Suction diffuser outlet shall be not less than pump suction size and suction diffuser system inlet shall be a minimum of one size larger than suction diffuser outlet size. Suction diffuser shall provide for a smooth flow of water into the pump inlet, and shall be complete with strainer, adjustable support leg, and start-up strainer. Start-up strainer shall be removed at the final testing and balancing phase.

2.3 PRESSURE GAUGES

- A. 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.

2.4 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:
- | | |
|---|------------------|
| Heating Water | 30-240 degrees F |
| Chilled Water, Condenser Water, Domestic Cold Water | 0-120 degrees F |
| Domestic Hot Water | 30-180 degrees F |

2.5 MANUAL AIR VENTS

- A. Provide manual air vents at locations indicated on the drawings, at the high point of all liquid piping system and as otherwise required for proper air elimination and liquid circulation.
- B. Manual air vents shall be 1/2" brass ball valves as specified in Section 23 0523. Provide brass hose connection and plug on valve outlet.

2.6 AUTOMATIC AIR VENT

- A. Provide automatic air vents for all separators, at the high point of all hydronic systems and at locations indicated on the drawings. Automatic air vents shall be 3/4" size, minimum. Provide manual shut-off ball valve between automatic air vent and piping system. Automatic air vents shall be float type, 150 PSIG maximum working pressure, 3/4" NPT system connection, Amtrol Model No. 720, Taco, Armstrong, Watson-McDaniel, Hofmann, or equivalent.

2.7 MANUAL DRAIN VALVES

- A. Provide manual drain valves at locations indicated on the drawings, at the low points of all liquid piping systems, and as otherwise required for proper draining of systems. Manual drain valves shall be sized as shown on the drawings but not less than 3/4" size, brass ball valve, as specified in Section 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.

2.8 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.

2.9 FLOW BALANCE VALVE

- A. Furnish and install calibrated balance valve equivalent to Bell and Gossett "circuit-setter," Griswold, Taco, Armstrong, or equivalent at locations indicated on the drawings. Balance valves shall be brass or cast iron body, NPT or sweat connections through 3" size and flanged connections above 4" size, 125 PSIG working pressure minimum. Balance valve shall be equipped with two brass readout valves with integral EPT insert and check valve designed to minimize system fluid loss during balancing and monitoring process. Each valve shall be provided with a calibrated nameplate permitting accurate system balance. Flow balance valves shall be not less than full line size with maximum pressure drop of 10 feet.

2.10 WATER FLOW MEASURING DEVICES

- A. Furnish and install cast iron wafer type flow meter equivalent to Bell & Gossett "OP-Series," Griswold, Taco, Armstrong, or equivalent at locations indicated in the drawings. Flow meters shall be equipped with two brass readout valves with integral EPT insert and check valve designed to minimize system fluid loss during monitoring process. Flow meter shall be furnished with a calibrated nameplate specifying the flow range through a range of differential pressures. Water flow measuring devices shall be not less than full line size with maximum pressure drop of 10 feet.

2.11 AUTOMATIC FLOW 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.

2.12 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°F through 12" size and operating pressure of 125 PSIG at 220°F for sizes 14" through 24". Provide butyl or Hypolon liner and applications with fluid temperatures in excess of 225°F.

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- B. Flexible connectors shall be single or twin sphere with Class 150 flange connections for sizes 2-1/2" and larger and threaded connections with galvanized female unions for sizes 3/4" through 2". Mason Industries MFTCR, Hyspan, Metra-Flex, Keflex, Proco, or equivalent. Flexible connectors required for outdoor installation shall be braided stainless steel type.
- C. Installation of flexible connectors shall be in strict accordance with manufacturer's recommendations. Spacing between piping system flanges shall be based on the flexible connector's expanded length corresponding to the system's operating pressure. Control rods or cables shall be provided for units installed in unanchored applications where system operating pressure and dynamic forces exceeds manufacturer's recommendations for unrestrained installations.

2.13 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.

2.14 AIR SEPARATOR

- A. Furnish and install air separator, inline or tangential type as shown on the drawings for all closed circuit hydronic system. Inline air separators shall be fabricated of steel or cast iron, 125 PSIG working pressure. Tangential type air separators shall be ASME code construction for 125 PSIG working pressure and shall be furnished with internal perforated stainless steel air collection tube, bottom blow down connection and removable stainless steel strainer element with 3/16" perforations and free area of not less than five times the cross-sectional area of the connecting piping.
- B. Each air separator shall be provided with an automatic air vent, 3/4" size, Amtrol Model No. 720 or equivalent, with manual shut-off ball valve between automatic air vent and air separator.
- C. Air separators shall be full line size and installed at the high point of the piping system unless otherwise indicated in the drawings.
- D. Air separators shall be Amtrol, Woods, Armstrong, Taco, or equivalent.

2.15 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.

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- B. For high water capacity applications provide Watts 2235B, Bell & Gossett, Amtrol, Cash, Jordan, or equivalent.
- C. Provide high or low pressure range depending on application requirements. Set pressure shall be as shown on the drawings, or as required to provide a minimum system pressurization of 12 PSIG at the system's highest point for closed circuit hydronic systems, or as recommended by equipment manufacturers.

2.16 WATER PRESSURE RELIEF VALVES

- A. Furnish and install ASME labeled, National Board Stamped, water pressure relief valves, Watts Series 174A or 740, Bell & Gossett, Amtrol, Cash, Jordan, or equivalent, 3/4" size minimum for relief of all water makeup to all closed circuit hydronic systems. Properly sized relief valves shall be provided where required for over-pressure protection on heat exchangers, converters, boiler, and pressure vessels, and other locations as shown in the drawings.
- B. Relief valves shall be sized for the full system heating capacity, to match the makeup capacity, or as otherwise required to protect the system from over-pressure conditions. Relief valves shall be factory pre-set for maximum pressure rating shown in the drawings, or for approximately 125% of the system operating pressure, but in no case shall the relief valve setting exceed the maximum safe operating pressure of the system and system components and equipment.

2.17 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°F maximum operating temperature and shall be furnished with the required valve thermostat tube extension length.

2.18 WATER REDUCED PRESSURE BACKFLOW PREVENTERS

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

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- C. Backflow protection devices associated with landscaping and irrigation systems shall be furnished and installed under the Site Work sections of these specifications.

2.19 CHEMICAL WATER TREATMENT

- A. Chemical water treatment for hydronic systems shall consist of equipment, start-up, testing, chemicals and one-year full service as listed on the Equipment Schedule, shown on the Drawings, and specified under the applicable piping system sections of this Specification.

2.20 FLOW METERS AND INSTRUMENTATION

- A. Water meters and instrumentation shall be furnished and installed as shown on the drawings and specified in Section 23 0900.

2.21 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.
- C. FLOW SWITCHES
- D. Furnish and install flow switches where required for protection and/or monitoring of mechanical equipment including water chillers, boilers, pumps, etc. and as otherwise shown on the equipment schedule, and the drawings.
- E. Flow switches shall be either paddle type or differential pressure type as required by the application and as shown on the drawings, except differential pressure type flow switches shall be utilized for water chillers and other applications where minor pressure fluctuation could cause nuisance tripping of equipment operation.
 1. Paddle type flow switch shall be McDonnell and Miller Model FS7-4 Series, or equivalent designed for industrial duty, brass body and trim, 300 PSIG maximum working pressure, paddle size as required for application, single pole double throw switches, with electrical rating of 7.4 full load amps at 115 VAC. Provide hazardous duty enclosure where required by the application. Flow switches shall be installed in a horizontal pipe with inlet and outlet conditions necessary to provide trouble-free operation.
 2. Differential pressure flow switch shall be Honeywell Model 406 Series or equivalent, adjustable pressure differential setting, dustproof mercury switch enclosure, 1/4" NPT bellows connections, single pole, single throw switch, with electrical rating of 7.2 full load

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amps at 115 vac. Differential pressure switches shall be properly supported on the equipment controlled or wall mounted adjacent to the equipment or piping system.

2.22 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°F maximum maintenance temperature and suitable for 185°F maximum exposure temperature, or Type HTSX medium temperature heating cable rated at 250°F maximum maintenance temperature and suitable for 420°F maximum exposure temperature, as required by the application and as manufactured by RayChem, 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. 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°F. Furnish and install piping labels on systems with electric heat tracing, manufacturer's standard (NEC code), labeled or stamped "ELECTRIC TRACED" labels shall be installed on the insulation pipe jacket at 10 foot intervals along the pipe on alternating sides.
- D. Electric Heat tracing system sizing shall be provided as recommended by the manufacturer to maintain pipe surface temperature at 34°F minimum during the winter based upon an outdoor design temperature of 0°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.

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- 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.

2.23 EXPANSION JOINTS

- A. Furnish and install corrugated bellows expansion joint, Hyspan Series 1500, Metra-Flex, Keflex, Proco, Flexonics, or equivalent, self-equalizing, 150 PSIG working pressure at 850°F, Class 150 ASA flange connections 1-1/2" size and above, single or dual center base configuration as shown on the drawings, constructed of corrugated Type 304 or 321 stainless steel, ring controlled, with integral stainless steel or Monel sleeve, and removable carbon steel external housing to protect bellows and support insulation. Furnish limit rods to prevent expansion joint from exceeding rated travel. Joint design shall be for maximum flexibility over 10,000 cycles minimum.
- B. Expansion joint sizing and installation shall be as shown on the drawing and as recommended by the manufacturer.
- C. Expansion joints shall be insulated with flexible 2" minimum thickness of high temperature fiberglass blanket insulation furnished with joint and installed under the external protective housing.
- D. Contractor shall carefully check expansion joint limit rods and make adjustments as required to ensure proper joint movement and operation.

2.24 EXPANSION COMPENSATORS

- A. Furnish and install expansion compensators, Hyspan series 8500, Metra-Flex, Keflex, Proco, Flexonics, or equivalent, stainless steel laminated bellows with stainless steel or carbon steel shroud, 175 PSIG pressure rating at 250°F, 2 inch straight line expansion and 1/2 inch contraction. Furnish copper tube with sweat ends for compensators installed in copper piping systems. Furnish standard wall carbon steel pipe tube for compensators installed in steel piping systems, threaded connectors for sizes 2" and smaller and Class 150 ASA flange connection for sizes 2-1/2" or larger.
- B. Expansion compensators sizing and installation shall be as shown on the drawings and as recommended by the manufacturer.

2.25 PIPE ALIGNMENT GUIDES

- A. Furnish and install factory fabricated steel pipe alignment guides, Hyspan Series 9500, Metra-Flex, Keflex, Proco, Flexonics, or equivalent, to maintain the longitudinal position of pipe centerline between expansion joints and compensators with axial restraint. Alignment guides shall consist of a bolted two-section outer cylinder and base with two-section guiding spider bolted tight to the pipe guide. Guide and spider shall be sized to clear pipe and pipe insulation and long enough to prevent over travel of spider and cylinder. Guides shall not be used for pipe support.

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- B. Alignment guides shall be arranged and installed as shown on the drawings and as recommended by the manufacturer.

2.26 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.

PART 3 EXECUTION

3.1 INSTALLATION

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

3.2 AIR VENTS

- A. Manual air vents shall be installed as specified herein and at the high points in all piping systems.
- B. Automatic air vents shall be installed as specified herein and at locations indicated on the drawings. Automatic air vents shall be installed level and in accordance with manufacturer's directions to properly vent system, complete with individual isolation valves.

3.3 STRAINERS

- A. All strainer screens, including basket strainers and suction diffusers, shall be removed and cleaned prior to commencing testing and balancing work and shall be maintained clean through project final acceptance by the Owner. Suction diffuser start-up strainers shall be removed prior to final system testing and balancing work.

3.4 TEST AND ADJUSTMENT

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

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- B. Field test and verify the operation of all safety devices including water relief valves and temperature and pressure relief valves.

3.5 RELIEF VALVE DISCHARGE

- A. Water pressure relief valve and water temperature and pressure relief valve discharges shall be piped full size to the outside of the building or discharged indirectly in a properly sized building floor drain or floor sink, and as allowed by the Building Mechanical and Plumbing Codes. When the operating discharge temperature is in excess of 212°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

SECTION 23 0523 VALVES

PART 1 GENERAL

1.1 REQUIREMENTS

- A. All Valves shall conform with current applicable provisions of the General Conditions, Supplemental General Conditions, and General Requirements.
- B. All Valves shall meet the current MSS Specifications covering Bronze & Iron Valves. MSS-SP-80, MSS-SP-70, MSS-SP71, MSS-SP-85 where applicable.
- C. Lead Ban: All systems and system components, pipe, fittings, and fixtures delivering water for human consumption shall be lead free.
 - 1. Any product designed for dispensing potable water shall meet both the NSF 61 and NSF 372 test standards via third-party testing and certification.
 - 2. Lead free refers to <0.25% weighted average lead content in relation to wetted surface of pipe, fittings, and fixtures in systems delivering water for human consumption, and solder and flux which does not contain more than 0.2% lead.

1.2 RELATED SECTIONS

- A. Section 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°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.

PART 2 PRODUCTS

2.1 GENERAL SERVICE VALVES, HVAC AND PLUMBING SYSTEMS

- A. Gate Valves - 2" and Smaller, Class 125: Valves 2" and smaller shall be cast of ASTM B-62 bronze, Class 125 construction, solid disc, rising stem, gland packed, non-asbestos packing. Milwaukee 148 (Threaded) or equivalent; Milwaukee 149 (Solder), or equivalent.
- B. Gate Valves - 2" and Smaller, Class 150: Valves 2" and smaller shall be cast of ASTM B-62 bronze, Class 150 construction, solid wedge disc, rising stem, union bonnet, gland packed, non-asbestos packing. Milwaukee 1151 (Threaded) or equivalent; Milwaukee 1169 (Solder), or equivalent
- C. Gate Valves - 2" and Smaller, Class 300: Valves 2" and smaller shall be cast of ASTM B-62 bronze, Class 300 construction, solid wedge disc, rising stem, union bonnet, gland packed, non-asbestos packing. Milwaukee 1184 (Threaded) or equivalent.
- D. Gate Valves - 2-1/2" and Larger, Class 125: Valves 2-1/2" and larger shall be of ASTM A-126 Class B cast iron, flanged ends, Class 125 construction, OS & Y Type, rising stem, bronze trim, non-asbestos packing. Milwaukee F2885 or equivalent.

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- E. Gate Valves - 2-1/2" and Larger, Class 250: Valves 2-1/2" and larger shall be of ASTM A-126 Class B cast iron, flanged ends, Class 250 construction, OS & Y Type, rising stem, bronze trim, non-asbestos packing. Milwaukee F2894 or equivalent.
- F. Globe Valves - 2" and Smaller, Class 125: Valves 2-1/2" and smaller shall be of ASTM B-62, Class 125 construction, bronze trim, gland packed, non-asbestos packing. Milwaukee 502 (Threaded), or equivalent; Milwaukee 1502 (Solder) or equivalent.
- G. Globe Valves - 2" and Smaller, Class 150: Valves 2" and smaller shall be of ASTM B-62, bronze, Class 150 construction, bronze trim, composition disc, union bonnet, gland packed, non-asbestos packing. Milwaukee 590 (Threaded) or equivalent; Milwaukee 1590 (Solder), or equivalent.
- H. Globe Valves - 2" and Smaller, Class 300: Valves 2" and smaller shall be of ASTM B-62, bronze, Class 300 construction, bronze trim, union bonnet, gland packed, non-asbestos packing. Milwaukee 572 (Threaded) or equivalent
- I. Globe Valves - 2-1/2" and Larger, Class 125: Valves 2-1/2" and Larger shall be of ASTM A-126, Class B cast iron, flanged ends, Class 125 construction, bolted bonnet, gland packed, non-asbestos packing. Milwaukee F2981M or equivalent.
- J. Globe Valves - 2-1/2" and Larger, Class 300: Valves 2-1/2" and larger shall be of ASTM A-126, Class B cast iron, flanged ends, Class 300 construction, bolted bonnet, gland packed, non-asbestos packing. Milwaukee F2983 or equivalent.
- K. Check Valves - 2" and Smaller, Class 125: Valves 2" and smaller shall be cast of ASTM B-62 bronze, Class 125 construction, Y-pattern, swing type design, teflon seat, disc for steam service, Buna-N for water service. Milwaukee 509 (Threaded) or equivalent; Milwaukee 1509 (Solder) or equivalent.
- L. Check Valves - 2" and Smaller, Class 150: Valves 2" and smaller shall be cast of ASTM B-62 bronze, Class 150 construction, Y-pattern, swing type design, bronze seat, composition disc, teflon seat disc for steam service, Buna-N for water service. Milwaukee 510 (Threaded) or equivalent; Milwaukee 1510 (Solder) or equivalent.
- M. Check Valves - 2" and Smaller, Class 300: Valves 2" and smaller shall be cast of ASTM B-62 bronze, Class 300 construction, Y-pattern, swing type design, bronze regrinding disc. Milwaukee 507 (Threaded) or equivalent.
- N. Check Valves - 2 1/2" and Larger, Class 125: Valves 2-1/2" and larger shall be of ASTM A-126 Class B, cast iron, flanged ends, Class 125 construction, bolted bonnet, bronze trim, swing type design. Milwaukee F2974M or equivalent.
- O. Check Valves - 2 1/2" and Larger, Class 250: Valves 2-1/2" and larger shall be of ASTM A-126 Class B, cast iron, flanged ends, Class 250 construction, bolted bonnet, bronze trim, swing type design. Milwaukee F2970 or equivalent.

2.2 STEAM SERVICE - ABOVE 80 PSIG TO 125 PSIG, MAXIMUM STEAM PRESSURE

- A. 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.
- B. Ball Valves - 2" and Smaller, Class 250: Valves 2" and smaller shall be cast of ASTM B-584 bronze, Class 250 construction, thread connections 316 stainless steel ball and stem, multi-fill PTFE seals and stem packing, adjustable packing gland and blowout-proof stem. Apollo 70-140-64 Series or equivalent.
- C. Gate Valves - 2 1/2" and Larger, Class 125:
 - 1. 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.
 - 2. Provide factory installed glove valve bypass 1/2" size through 4" valve size, 3/4" size for 6" and 8" valve sizes and 1" for valve sizes 10" and larger, conforming to MSS specification SP.45.
 - 3. Provide drilled and tapped hoses for drains conforming to SP-45 where shown on drawings and as required for proper installation.
 - 4. Milwaukee F2885 or equivalent.
- D. Globe Valves - 2" and Smaller, Class 150: Valves 2" and smaller shall be cast of ASTM B-62 bronze, Class 150 construction, bronze trim, composition disc, union bonnet, gland packed, non-asbestos packing. Milwaukee 590 (Threaded) or equivalent.
- E. 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, bronze trim, gland packed, non-asbestos packing. Milwaukee F2981 or equivalent.
- F. 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 seats, composition disc, teflon seat disc for steam service, Buna-N for water service. Milwaukee 510 (Threaded) or equivalent.
- G. Check Valves - 2-1/2" and Larger, Class 125: Valves 2-1/2" and larger shall be cast of ASTM B-62 bronze, Class B, cast iron, flanged ends, Class 125 construction, bolted bonnet, bronze trim, swing type design. Milwaukee F2974M (Threaded) or equivalent.

2.3 STEAM SERVICE - ABOVE 125 PSIG TO 150 PSIG, MAXIMUM STEAM PRESSURE

- A. Gate Valves - 2" and Smaller, Class 150: Valves 2" and smaller shall be bronze Class 150 construction, threaded connections. Milwaukee 1151 or equivalent as specified herein or equivalent.
- B. Gate Valves - 2 1/2" and Larger, Class 250:

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1. 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.
2. Provide factory installed glove valve bypass 1/2" size through 4" valve size, 3/4" size for 6" and 8" valve sizes and 1" for valve sizes 10" and larger, conforming to MSS specification SP-45.
3. Provide drilled and tapped hoses for drains conforming to SP-45 where shown on drawings and as required for proper installation.
4. Milwaukee F2894 or equivalent.

2.4 STEAM CONDENSATE VALVES

- A. Gate Valves - 2" and Smaller, Class 150: Valves 2" and smaller shall be bronze, Class 150 construction. Milwaukee 1151 (threaded), Milwaukee 1169 (solder), as specified herein or equivalent.
- B. Gate Valves - 2-1/2" and Larger, Class 125: Valves 2-1/2" and larger shall be cast iron, Class 125 construction, OS & Y pattern. Milwaukee F-2885, as specified herein or equivalent.
- C. Check Valves - 2 1/2" and Smaller, Class 150: Valves 2-1/2" and smaller shall be bronze, Class 150 construction, threaded connections, Milwaukee 510, as specified herein or equivalent.
- D. Check Valves - 2 1/2" and Larger, Class 125: Valves 2-1/2" and larger shall be cast iron, Class 125 construction, flanged connections. Milwaukee F2974M, as specified herein or equivalent.

2.5 BOILER FEED WATER PUMP DISCHARGE AND RECIRCULATING VALVES (HIGH PRESSURE)

- A. Gate Valves - 2" and Smaller, Class 300: Valves 2" and smaller shall be cast of ASTM B-62 bronze, Class 300 construction, 600 PSI W.O.G., solid wedge disc, rising stem, stainless steel seats and wedge, union bonnet, gland packed, non-asbestos packing, threaded connections. Milwaukee 1184M or equivalent.
- B. Gate Valves - 2 1/2" and Larger, Class 250: Valves 2-1/2" and larger shall be cast iron, Class 250 construction, 500 PSI W.O.G., flanged connections, OS & Y Type. Milwaukee F-2894 as specified herein or equivalent.
- C. Check Valves - 2" and Smaller, Class 300: Valves 2" and smaller shall be cast of ASTM B-62 bronze, Class 300 construction, 600 PSI W.O.G., Y-pattern, swing type design, bronze regrinding disc, threaded connections. Milwaukee 507 or equivalent.
- D. Check Valves - 2-1/2" and Larger, Class 250: Valves 2-1/2" and larger shall be cast of ASTM A-126, Class B cast iron, flanged ends, Class 250 construction, 500 PSI W.O.G., bolted bonnet, bronze trim, swing type design. Milwaukee F-2970 or equivalent.

2.6 BOILER FEED WATER PUMP DISCHARGE & RECIRCULATING VALVES (LOW PRESSURE)

- A. Gate Valves - 2" and Smaller, Class 150: Valves 2" and smaller shall be bronze, Class 150 construction, 300 PSI W.O.G., threaded connections. Milwaukee 1151 as specified herein or equivalent.
- B. Gate Valves - 2 1/2" and Larger, Class 125: Valves 2-1/2" and larger shall be cast iron, Class 125 construction, 200 PSI W.O.G., OS & Y Type. Milwaukee F-2885, as specified herein or equivalent.
- C. Check Valves - 2" and Smaller, Class 150: Valves 2" and smaller shall be bronze, Class 150 construction, 300 PSI W.O.G., threaded connections. Milwaukee 510, as specified herein or equivalent.
- D. Check Valves - 2 1/2" and Larger, Class 125: Valves 2-1/2" and larger shall be cast iron, Class 125 construction, 200 PSI W.O.G., flanged connections, OS & Y Type. Milwaukee F-2974M, as specified herein or equivalent.

2.7 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°F to 275°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.

2.8 BALL VALVES

- A. Valves 2" and smaller shall be cast of ASTM B-62 bronze, Class 150 construction, 600 PSI W.O.G. Two-piece body, chrome plated ball, blowout proof stem, reinforced TFE seats, non-asbestos packing. Milwaukee BA-100 (threaded) or equivalent. Milwaukee BA-150 (solder) or equivalent.
- B. Valves installed on insulated services shall be provided with extensions, as required, such that operator does not interfere with insulation or insulation jacketing. Cutting or notching of the insulation or bending of handles shall not be permitted.

2.9 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
- D. Flow control and Flow Balance Valves: For calibrated flow balance valves and automatic flow control valves, see Specification Section 23 0505, Piping Specialties.

2.10 NATURAL GAS VALVES

- A. Valves 3/4" and Smaller: Bronze natural gas cock, Walworth No. 590 (square head), Walworth 591 (flat head) or equivalent.
- B. Valves 3" and Smaller: Ball valve shall be cast of ASTM B-584 bronze, Class 250 construction, threaded connections, chrome plated big ball and stem, RDTFE seat and stem packing, blow-out proof stem, UL Listed for natural gas service, Apollo 80-100 Series or equivalent.
- C. Valves 4" and Larger: Lubricated plug valve, cast iron construction, 175 PSIG W.O.G., threaded connection for valves 2" and smaller, Class 125 Flange connections, level handle operator. Walworth No. 1797F (Flanged) or equivalent.

2.11 MANUAL AIR VENTS AND DRAIN VALVES

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

2.12 BOILER SPECIALTY VALVES

- A. For boiler stop-check valves blow-down valves, and relief valves, see Specification Section 23 2213, Steam and Condensate System.

2.13 NON-SLAM SILENT CHECK VALVE

- A. Check valves for pump discharge and other required non-slam silent operation, shall be center guided, suitable for vertical or horizontal installation position, cast iron in semi-steel body,

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bronze disc and trim, stainless steel spring, Buna-N seats, Class 125 or 250 construction, as required by the application, wafer or globe flanged pattern for valves 2" through 10" size and flanged pattern for valves 12" and larger. Milwaukee 1400 Series (wafer) or equivalent. Milwaukee 1800 Series (globe) or equivalent.

2.14 TRIPLE DUTY VALVE

- A. At the Contractor's option, triple duty valve may be utilized at pump discharge in lieu of non-slam check valve and balance/shut-of valve, see Specifications Section 23 0505, Piping Specialties.

PART 3 EXECUTION

3.1 INSTALLATION

- A. All valves shall be installed in locations which will allow easy operation and facilitate maintenance.
- B. Gate and Globe valves shall be installed with stems horizontal.

END OF SECTION

SECTION 23 0548 VIBRATION AND SEISMIC CONTROLS FOR HVAC

PART 1 GENERAL

1.1 REQUIREMENTS

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

1.2 RELATED SECTIONS

- A. Section 23 0500, Common Work Requirements for HVAC.
- B. Section 23 0504, Pipe and Pipe Fittings.

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 23 0500 for general requirements for submittal materials. In addition to the requirements contained in Section 23 0500, provide submittal information for all products and materials covered under this Section of the Specifications as listed herein.

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- 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 and ductwork; method of isolation for piping and ductwork passing through the building structure; and location and arrangement of seismic restraints.
- D. Manufacturers not listed as approved in 'Part 2 - Products' of this section 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 23 of this Specification in accordance with the requirements of the 2006 International Building Code; and NFPA No. 13 for fire protection system as adopted and interpreted by the State of New Mexico for Seismic Zone D, Risk Category IV.

1.6 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 mechanical equipment, ductwork and piping systems are properly supported to resist earthquake forces as required herein.
- B. All mechanical 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 for Seismic Zone D.
- C. All items of mechanical 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 for Seismic Zone D.
- D. All items of mechanical equipment, except as specified above, and all piping and ductwork furnished and installed under Division 23 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.

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

PART 2 PRODUCTS

2.1 VIBRATION ISOLATORS

- A. Floor mounted vibration isolators shall be either spring isolators designed for seismic restraint application or pre-compressed molded fiberglass or ribbed neoprene units as specified herein and in the Mechanical Equipment Schedule on the drawings. All vibration isolated equipment shall employ seismic snubbers having an approved "R" rating issued by the State of New Mexico.
- B. Hanger type vibration isolators shall consist of steel springs in series with neoprene element as scheduled and specified on the drawings.
- C. All vibration isolation devices shall be furnished by a single manufacturer to assure sole source responsibility for the proper performance of the materials used.
- D. Vibration isolators shall be provided to maintain a minimum of 1-inch operating clearance.
- E. Vibration isolators shall have a minimum static deflection as specified on the drawings. Isolators shall be selected by the manufacturer for non-resonance with the equipment forcing frequency and the building structure's natural frequencies. Isolators shall be provided for suitable mounting to equipment and supporting structure.
- F. Vibration isolators shall be furnished by Kinetics Noise Control, Mason, or equivalent.

2.2 EQUIPMENT BASES

- A. Vibration isolation bases shall be supplied by the vibration isolation manufacturer as indicated on the drawings and as required for the application. Concrete for inertia bases shall be furnished and installed by the Contractor and shall comply with Division 3 requirements.
- B. Structural steel bases shall be designed and supplied by the isolator manufacturer. Kinetics Noise Control Type SFB, or equivalent. Bases shall be designed with isolator brackets to reduce the mounting height of the equipment. To assure adequate stiffness, the height of the members shall be a minimum of 8% of the longest span between isolators, or at least 6 inches. Where thinner sections are necessary, due to head room limitations, etc., the section modules of the members selected shall equal or exceed the section modules of wide flange steel members whose thickness is 8% of the longest span between isolators.
- C. Reinforced concrete inertia bases shall be designed by the isolation manufacturer who shall furnish the steel framework, Kinetics Noise Control, CIB, or equivalent. The Contractor shall furnish and install concrete, poured into the welded steel frame. The steel framework shall

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incorporate pre-located equipment anchor bolts, 1/2" diameter reinforcing bars on nominal 8" centers each way, and recessed isolator mounting brackets to reduce the mounting height of the equipment, but yet remain within the confines of the base. The thickness of the base shall be a minimum of 8% of the longest span between isolators, at least 6", or as indicated on the drawings. Where inertia bases are used to mount pumps, the bases shall be wide enough to support piping elbows. Provide a minimum of 1-inch clearance between the bottom of the base and floor on housekeeping pad with equipment in place, in operation and with spring isolators properly adjusted.

2.3 FLEXIBLE CONNECTIONS

- A. Flexible connections for piping systems shall be as specified in Section 23 0504. Flexible connection for fan equipment and flexible ductwork shall be as specified in Section 23 3000.

2.4 SEISMIC SNUBBER TYPES

- A. Reference: ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.) Handbook, 2007 HVAC Applications, Chapter 54 'Seismic and Wind Restraint Design'.
- B. Type A: Coil Spring Isolator Incorporated within a Ductile Iron or Cast Aluminum Housing:
 - 1. Cast iron or aluminum housing are brittle when subjected to shock loading and are therefore not approved for seismic restraint applications.
- C. Type B: Coil Spring Isolator Incorporated within a Steel Housing:
 - 1. Spring isolators shall be seismic control restrained spring isolators, incorporating a single or multiple coil spring element, having all of the characteristics of free standing coil spring isolators as specified in the vibration isolation portion of this specification. Springs shall be restrained using a housing engineered to limit both lateral and vertical movement of the supported equipment during an earthquake without degrading the vibration isolation capabilities of the spring during normal equipment operating conditions.
 - 2. Vibration isolators shall incorporate a steel housing and neoprene snubbing grommet system designed to limit motion to no more than 1/4" in any direction and to prevent any direct metal-to-metal contact between the supported member and the fixed restraint housing. The restraining system shall be designed to withstand the seismic design forces in any lateral or vertical direction without yield or failure. Where the capacity of the anchorage hardware in concrete is inadequate for the required seismic loadings, an adapter baseplate to allow the addition of more or larger anchors will be fitted to fulfill these requirements. In addition to the primary isolation coil spring, the load path will include a minimum 1/4" thick neoprene pad.
 - 3. Spring elements shall be color coded or otherwise easily identified. Springs shall have a lateral stiffness greater than 1.2 times the rated vertical stiffness and shall be designed to provide a minimum of 50% overload capacity. Non-welded spring elements shall be epoxy power coated and shall have a minimum of a 1,000 hour rating when tested in accordance with ASTM B-117.

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4. To facilitate servicing, the isolator will be designed in such a way that the coil spring element can be removed without the requirement to lift or otherwise disturb the supported equipment.
5. Spring isolators shall be Model FHS or FMS Isolator/restraint as manufactured by Kinetics Noise Control, or by other manufacturer's who can meet the requirements as specified herein.

D. Type C: Coil Spring Isolator Incorporated within a Steel Housing:

1. Spring isolators shall be seismic control restrained spring isolators, incorporating one or more coil spring elements, having all of the characteristics of free standing coil spring isolators per the vibration isolation section of this specification, for equipment which is subject to load variations and/or large external forces. Isolators shall consist of one or more laterally stable steel coil springs assembled into fabricated welded steel housings designed to limit movement of the supported equipment in all directions.
2. Housing assembly shall be made of fabricated steel members and shall consist of a top load plate complete with adjusting and leveling bolts, adjustable vertical restraints, isolation washers, and a bottom load plate with internal non-skid isolation pads and holes for anchoring the housing to the supporting structure. Housing shall be hot dipped galvanized for outdoor corrosion resistance. Housing shall be designed to provide a constant free and operating height within 1/8".
3. The isolator housing shall be designed to withstand the project design seismic forces in all directions.
4. Coil spring elements shall be selected to provide static deflections as shown on the vibration isolation schedule or as indicated or required in the project documents. Spring elements shall be color coded or otherwise easily identified. Springs shall have a lateral stiffness greater than 1.2 times the rated vertical stiffness and shall be designed to provide a minimum of 50% overload capacity. Non-welded spring elements shall be epoxy powder coated and shall have a minimum of 1,000 hour rating when tested in accordance with ASTM B-117.
5. Spring isolators shall be Model FLSS as manufactured by Kinetics Noise Control, or by other manufacturers who can meet the requirements as specified herein.

E. Type D: Coil Spring Isolator Incorporated within a Steel Housing:

1. Spring isolators shall be lateral restrained spring isolators, incorporating a single coil spring element, having all of the characteristics of free standing coil spring isolators as previously specified. Springs shall be assembled into a welded steel housing engineered to limit lateral movement of supported equipment during an earthquake without degrading the vibration isolation capabilities of the spring during normal operating conditions.
2. Vibration isolators shall incorporate a steel angle and plate motion limiting assembly and steel coil spring, designed as a system to accept a force in any lateral direction in excess of the design seismic requirement for the isolator without yield or failure. Isolator shall limit lateral movement of the equipment to less than 1/4" in any direction. The lateral limit stop shall incorporate a neoprene grommet to prevent the potential for metal-to-metal contact. The vibration isolation element shall include a 1/4" thick ribbed neoprene noise stop pad, positioned outside of the housing anchorage path. The housing shall incorporate drilled holes for attachment to the supporting structure.

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3. Spring isolators shall be Model FYS as manufactured by Kinetics Noise Control, or by other manufacturers who can meet the requirements as specified herein.
- F. Type E: All Direction Neoprene Isolator:
1. Vibration isolators shall be neoprene, molded from oil resistant compounds, designed to operate within the strain limits of the isolator so to provide the maximum isolation and longest life expectancy possible using neoprene compounds. Isolators shall include encapsulated cast-in-place top steel load transfer plate for bolting to equipment and a steel baseplate with anchor holes for bolting to the supporting structure. Ductile iron or cast aluminum components are not acceptable alternatives and shall not be used due to brittleness when subjected to shock loading.
 2. Isolator shall be capable of withstanding the design seismic loads in all directions with no metal-to-metal contact.
 3. Isolator shall have minimum operating static deflections as shown on the project vibration isolation schedule or as otherwise indicated in the project documents and shall not exceed published load capacities.
 4. Neoprene isolators shall be Model RQ as manufactured by Kinetics Noise Control, or by other manufacturers who can meet the requirements as specified herein.
- G. Type F: All Direction External Seismic Snubber Assembly:
1. Equipment shall be restrained against excessive movement during a seismic event by the use of 3-axis resilient snubbers, designed to withstand the project required seismic forces.
 2. Snubbers shall be of welded steel construction and shall be attached to the equipment structure and equipment in a manner consistent with anticipated design loads. Snubbers shall limit lateral and vertical equipment movement at each snubber location to a maximum of 1/4" in any direction.
 3. Snubbers shall include a minimum of 1/4" thick resilient neoprene pads to cushion any impact and to avoid any potential for metal-to-metal contact. Maximum neoprene bearing pressure shall not exceed 1500 pounds/Sq. Inch. Snubber shall be installed only after the isolated equipment is mounted, piped, and operating so as to ensure that no contact occurs during normal equipment operation.
 4. Three-axis seismic snubbers shall be Model HS-5/7 as manufactured by Kinetics Noise Control, or by other manufacturer's who can meet the requirements as specified herein.
- H. Type G: All Direction Lateral External Seismic Snubber Assembly:
1. Equipment shall be restrained against excessive lateral movement during a seismic event by the use of 2-axis horizontal resilient snubbers, designed to withstand the project required seismic forces.
 2. Snubbers shall be of welded steel construction and shall be attached to the equipment structure and equipment in a manner consistent with anticipated design loads. Snubbers shall limit lateral equipment movement at each snubber location to a maximum of 1/4".
 3. Snubbers shall include a minimum of 1/4" thick resilient neoprene pads to cushion any impact and to avoid any potential for metal-to-metal contact. Snubber shall be installed only after the isolated equipment is mounted, piped and operating so as to ensure that no contact occurs during normal equipment operation.

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4. Two-axis lateral seismic snubbers shall be Model HS-2 as manufactured by Kinetics Noise Control, or by other manufacturer's who can meet the requirements as specified herein.
- I. Type H: Two-Axis External Seismic Snubber Assembly:
1. Equipment shall be restrained against excessive vertical and horizontal movement during a seismic event by the use of 2-axis resilient snubbers, designed to withstand the project required seismic forces. A minimum of four (4) snubbers are to be used at each equipment installation, oriented to effectively restrain the isolated equipment in all three directions.
 2. Snubbers shall be of welded steel construction and shall be attached to the equipment structure and equipment in a manner consistent with anticipated design loads. Snubbers shall limit lateral and vertical equipment movement at each snubber location to a maximum of 1/4" in any direction.
 3. Snubbers shall include resilient neoprene pads within a minimum thickness of 1/4" to cushion any impact and to avoid any potential for metal-to-metal contact. Snubber shall be installed only after the isolated equipment is mounted, piped, and operating so as to ensure that no contact occurs during normal equipment operation.
 4. Two-axis seismic snubbers shall be Model HS-4 as manufactured by Kinetics Noise Control, or by other manufacturer's who can meet the requirements as specified herein.
- J. Type I: Single-Axis External Seismic Snubber Assembly:
1. Equipment shall be restrained against excessive horizontal one-axis movement during a seismic event by the use of single-axis resilient snubbers, designed to withstand the project required seismic forces. A minimum of four (4) snubbers are to be used at each equipment installation, oriented to effectively restrain the isolated equipment in all lateral directions.
 2. Snubbers shall be of welded steel construction and shall be attached to the equipment structure and equipment in a manner consistent with anticipated design loads. Snubbers shall limit lateral equipment movement at each snubber location in the direction of impact to a maximum of 1/4".
 3. Snubbers shall include resilient neoprene pads within a minimum thickness of 1/4" to cushion any impact and to avoid any potential for metal-to-metal contact. Snubber shall be installed only after the isolated equipment is mounted, piped, and operating so as to ensure that no contact occurs during normal equipment operation.
 4. Single-axis seismic snubbers shall be Model HS-1 as manufactured by Kinetics Noise Control, or by other manufacturer's who can meet the requirements as specified herein.
- K. Type J: Cable Restraints for Suspended Piping and Ductwork:
1. Seismic wire rope cable restraints shall consist of steel wire strand cables, sized to resist seismic loads, arranged so to offer seismic restraint capabilities for piping, ductwork, and suspended equipment in all lateral directions.
 2. End connection fittings shall be designed to swivel in order to ensure proper cable alignment and to avoid bending of rope. Protective thimbles shall be used at connection points so to eliminate bending cable across sharp edges.

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3. Anchoring hardware at each end of the cable shall be designed so to exceed the working project design load of the wire cable by a minimum of 50 percent.
4. Seismic cable restraints shall be Model SCR as manufactured by Kinetics Noise Control, or by other manufacturer's who can meet the requirements as specified herein.

2.5 SEISMIC RESTRAINTS

- A. Seismic restraints shall be furnished and installed as specified herein and as required. Installation of all seismic restraint materials specified herein shall be accomplished following the manufacturer's written instructions. Installation instructions shall be submitted to the Engineer for approval prior to the beginning of the work.
- B. All mechanical equipment not mounted on spring isolators shall be provided with seismic restraints, as specified and detailed on the drawings, designed to restrain movement in vertical and horizontal directions during a seismic condition.
- C. All ductwork, piping systems, and suspended equipment including air terminal units shall be supported to resist seismic forces in accordance with SMACNA guidelines or by means of an approved bracing system equivalent to Kinetics, Pipe Shields Incorporated, or Mason. The seismic restraint manufacturer shall provide documentation on maximum restraint spacing for various cable sizes and anchors, as well as worst case reaction levels at restraint locations.
- D. All seismic snubber restraint assemblies shall meet the following minimum requirements:
 1. Impact surface should have a high quality elastomeric facing so to ensure that no metal-to-metal contact can occur.
 2. Resilient material should be easy to visually inspect for damage and be replaceable if necessary.
 - a. Resilient material used in snubber assemblies to be a minimum of 0.25" thick.
 - b. Resilient material used in snubber grommets to be a minimum of 0.12" thick.
 3. Assembly must be designed to offer seismic restraint in all directions, unless otherwise noted below.
 4. Clearance between resilient material and contacting isolated equipment surface must not exceed 0.25".
 5. Seismic restraints capacities to be verified by an independent test laboratory or certified by a registered State of New Mexico Structural Engineer who is experienced in seismic restraint design to ensure that the design intent of this specification is realized.
- E. The Contractor shall ensure that all housekeeping pads used are adequately reinforced and are properly attached to the building structural flooring, so to withstand anticipated seismic forces. In addition, the size of the housekeeping pad is to be coordinated with the seismic restraint manufacturer so to ensure that adequate edge distances exist in order to obtain desired design anchor capabilities.

PART 3 EXECUTION

3.1 GENERAL

- A. All mechanical equipment scheduled on the drawings shall be isolated from building structure by means of resilient vibration and noise isolators supplied by a single manufacturer to the Contractor. The isolator manufacturer shall submit a tabulation of the design data on the isolators including spring O.D., free operating and solid heights of springs, free and operating heights of neoprene isolators. Static deflection scheduled is the minimum acceptable and represents the static deflection required based on the combined weight of the equipment; motor bases and any other accessories specified in the mechanical equipment schedule. Isolation bases shall be furnished by the Vibration Isolator Manufacturer. Vibration isolation system shall have a maximum lateral motion under equipment start-up and shutdown conditions of 1/4-inch. Restrain excess motion by spring type mountings. Connections to equipment shall allow for deflections equal to or greater than equipment deflections.
- B. Seismic restraints shall be in accordance with the State of New Mexico requirements and the Uniform Building Code, and shall be designed to resist seismic forces of magnitudes as specified herein. Installation of seismic restraints shall follow SMACNA guidelines.
- C. The Contractor shall coordinate the installation of the vibration isolation and seismic restraint devices with all trades and subcontractors. Contractor shall verify with the Architect that the devices and supports are adequate as intended and do not overload the building structural components in any way. The exact method and means of connection of the mechanical system to the building structural system shall be approved by the Architect.
- D. Installation of all seismic restraint materials specified in this section shall be accomplished as per the manufacturer's written instructions.
- E. Upon completion of installation of all seismic restraint materials and before start up of restrained equipment, all debris shall be cleaned from beneath all protected equipment, leaving equipment free to contact snubbers.
- F. No rigid connections between the equipment and the building structure shall be made which degrades the seismic restraint system herein specified. All electrical conduit to restrained equipment shall be looped to allow free motion of equipment without damage to the electrical wiring.

3.2 EQUIPMENT CONNECTIONS

- A. No rigid connections between equipment and building structure shall be made that degrades the noise and vibration isolation system herein specified.
- B. Electrical circuit connections to isolated equipment shall be looped to allow free motion of isolated equipment; see Division 26.

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- C. Coordinate work with other trades to avoid rigid contact with the building. Inform other trades following work, such as plastering or electrical, to avoid any contact which would reduce the vibration isolation.

3.3 EQUIPMENT ISOLATORS

- A. The minimum operating clearance between the equipment frame or the equipment vibration base frame and the housekeeping pad or floor shall be 1".
- B. The equipment vibration base shall be placed in position and supported temporarily by blocks or shims, as appropriate, prior to the installation of the machine or isolators.
- C. After the entire installation is complete and under full operational load, the isolator shall be adjusted so that the load is transferred from the blocks to the isolator. When all isolators are properly adjusted, the blocks or shims shall be free and shall be removed.
- D. Isolator static deflection shall be (minimum) as specified or scheduled on the Drawings.
- E. Position all corner or side seismic restraints with equipment operation for proper operating clearance and weld or bolt seismic restraint to seismic anchor plates in housekeeping pad.
- F. Install equipment with flexibility in piping and wiring connections.
- G. Verify all installed isolators and mounting systems permit equipment motion in all directions. Adjust or provide additional resilient restraints to limit start-up equipment lateral motion to 1/4".
- H. Prior to start-up, clean out all foreign matter between bases and equipment. Verify that there are no isolation short circuits in the base, isolators or seismic restraints.

3.4 SEISMIC RESTRAINT FOR PIPING

- A. Seismically restrain all piping listed below. Use Type 'J' cable restraints for all piping supported by vibration isolation hanger assemblies, including:
 - 1. Natural gas piping, medical gas piping, vacuum piping, petroleum based liquid piping, and compressed air piping equal to or greater than 1" in inside diameter.
 - 2. All piping located within mechanical equipment and service rooms equal to or greater than 1-1/4" in inside diameter.
 - 3. All other piping equal to or greater than 2-1/2" in inside diameter.
- B. Type 'J' cable seismic restraint sizes, quantities, locations and mounting details per SMACNA (Sheet Metal and Air Conditioning Contractors National Association, Inc.) 'Seismic Restraint Manual Guidelines for Mechanical Systems,' Latest Edition.

3.5 SEISMIC RESTRAINT FOR DUCTWORK

- A. Seismically restrain all ductwork listed below. Use Type 'J' cable restraints or equivalent for all ductwork, including.
 - 1. All rectangular and oval ducts with cross sectional area equal to or greater than 6 square feet.
 - 2. All round ducts with diameters equal to or greater than 28".
 - 3. Type 'J' cable seismic restraint sizes, quantities, locations and mounting details per SMACNA (Sheet Metal and Air Conditioning Contractors National Association, Inc.) 'Seismic Restraint Manual Guidelines for Mechanical Systems', Latest Edition.

3.6 SEISMIC RESTRAINT FOR FIRE PROTECTION PIPING

- A. Fire protection, sprinkler piping and related equipment is considered as 'Life Safety Equipment' and shall be seismically restrained per guidelines as published by NFPA (National Fire Protection Association) as specified in Division 21.

3.7 PIPING, DUCTWORK AND CONDUIT EXCLUSIONS

- A. Per the IBC (International Building Code), piping and ductwork which have diameter or cross sectional areas less than those noted in Sections 3.4, 3.5, and 3.6 do not require additional seismic restraint over and above the normal suspension hardware.

3.8 INSPECTION

- A. The Contractor shall notify the local representative of the seismic restraint materials manufacturer's representative prior to installing any seismic restraint devices. The Contractor shall seek the representative's guidance in all installation procedures.
- B. The local representative of the seismic restraint and snubber materials manufacturer shall conduct periodic inspections, minimum of monthly during construction period for equipment, piping and ductwork seismic restraint system installation. Inspection reports shall be in writing to the Contractor any deviations from good installation practice observed. These reports shall be forwarded to the Architect for review.
- C. On completion of installation of all seismic restraint and vibration isolation devices herein specified, the vibration isolation manufacturer shall inspect the completed system and submit an inspection report to the Architect. This report shall identify any installation error, improperly selected isolation devices, or other problems that could affect the performance of the system. The manufacturer's report shall include recommendations for any actions required to properly complete the vibration isolation and seismic restraint work. The cost of the inspection shall be included in the contractor's bid price.

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- D. The installing Contractor shall submit a final report to the Project Architect and/or Engineer, including the manufacturer representative's final report, certifying that all seismic restraint material has been properly installed, or steps to be taken by the Contractor to properly complete the seismic restraint work per the specifications.

END OF SECTION

SECTION 23 0549 HVAC AND ELECTRICAL INSTALLATION COORDINATION

PART 1 GENERAL

1.1 REQUIREMENTS

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

1.2 RELATED DIVISIONS AND SECTIONS

- A. Section 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.

PART 2 PRODUCTS

Not Applicable.

PART 3 EXECUTION

3.1 INSTALLATION

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

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TABLE 1

Item or System	Note	Supplied By (3)	Installed By (3)	Powered By	Control Field Wiring By
Equipment Motors		Div. 23	Div. 23	Div. 26	N/A
Motor Control Center Including Starters, Pilot Lights, Heater, Switches, Auxiliary Contacts, and Internal Control Wiring		Div. 26	Div. 26	Div. 26	Div. 23
Stand Alone Motor Starters (outside motor control centers)	(1)	Div. 26	Div. 26	Div. 26	Div. 23
Variable Frequency Drives (VFD's)		Div. 23	Div. 23	Div. 26	Div. 23
Fused and Non-Fused Disconnects	(1)	Div. 26	Div. 26	Div. 26	N/A
Control Relays & Control Transformers	(1)	Div. 23	Div. 23	Div. 26	Div. 23
Central Plant/Refrigeration Equipment Room Emergency Shutdown & Ventilation		Div. 23	Div. 23	Div. 26	Div. 23
Cooling Tower Vibration Switches		Div. 23	Div. 23	Div. 26	N/A
Boilers		Div. 23	Div. 23	Div. 26	Div. 23
Refrigeration Gas Monitor		Div. 23	Div. 23	Div. 26	Div. 23
Kitchen Make-up System & Hood Exhaust Fans		Div. 23	Div. 23	Div. 26	Div. 26
Kitchen Exhaust Hoods & Lab Fume Hoods		Div. 23	Div. 23	Div. 26	N/A
Kitchen Hood Fire Protection System		Div. 23	Div. 23	Div. 26	N/A
Kitchen Hood Natural Gas Shut-Off Valve		Div. 11	Div. 23	Div. 26	N/A
Fan Coil Units Including		Div. 23	Div. 23	Div. 26	Div. 23
Water Chillers		Div. 23	Div. 23	Div. 26	N/A
Min. Outside Air Units Including Mixing Dampers		Div. 23	Div. 23	Div. 26	Div. 23
Rooftop A/C Units Including Mixing Dampers		Div. 23	Div. 23	Div. 26	Div. 23
HVAC Unit Smoke Detectors		Div. 28	Div. 23	Div. 28	Div. 28
Fire/Smoke Control Dampers & Smoke Dampers		Div. 23	Div. 23	Div. 26	Div. 28
Fan Coil Unit Condensate Float Switches		Div. 23	Div. 23	N/A	Div. 23
Supply, Return & Exhaust Fan with unit mounted 115 VAC 2-position damper actuators interlock with fan motor/starter		Div. 23	Div. 23	Div. 26	N/A
Non-FMS Control Devices Including Wall Switches, Timers, Thermostats		Div. 23	Div. 23	Div. 26	Div. 26
Chemical Treatment Systems		Div. 23	Div. 23	Div. 26	N/A
Cooling Tower Sand Filter Units		Div. 23	Div. 23	Div. 26	N/A
Facility Management System (FMS)	(2)	Div. 23	Div. 23	Div. 23	Div. 23

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Item or System	Note	Supplied By (3)	Installed By (3)	Powered By	Control Field Wiring By
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

SECTION 23 0593 TESTING, ADJUSTING AND BALANCING OF MECHANICAL SYSTEMS

PART 1 GENERAL

1.1 GENERAL

- A. Conform with applicable provisions of the General Provisions and the General Requirements.
- B. Testing, adjusting and balancing (TAB) shall be performed by a TAB Agency which is independent of the Mechanical Contractor.
- C. The TAB Agency's efforts shall be paid for by the Contractor and included in the mechanical contract price.
- D. Unless specifically noted, all work specified in this section shall be included in the scope of the TAB Agency's work. But some work described in this section is to be performed by the mechanical contractor, controls contractor, or others, and that work is specifically noted to be by these entities.

1.2 SCOPE

- A. Provide TAB for the systems and equipment installed under Division 23, including but not limited to:
 - 1. Supply and exhaust air systems including process and kitchen systems.
 - 2. Return air where specifically noted.
 - 3. Hydronic systems including domestic HW return systems.
- B. Provide all labor, instruments, and tools necessary to test, adjust and balance the systems shown on the drawings and/or described in these specifications. Check equipment performance, take measurements, adjust systems and equipment to provide specified performance, and report results. Submit reports to keep all parties posted on the progress of the TAB work.
- C. Where the TAB effort indicates deficiencies in system performance, TAB Contractor shall take the lead in a collaborative effort to trouble-shoot and resolve these deficiencies. Engage the assistance of others where necessary, starting with the Mechanical Contractor and Controls Subcontractor. Take additional measurements as required to identify the cause of the deficiencies, perform additional TAB as required to bring the system in compliance with the design intent. Engage the assistance of the Engineer and others where necessary. Indicate final setpoints and readings in a final TAB report.
- D. Include three days of effort on site for tests and/or balancing as directed in writing by the Owner's Representative beyond that described herein, but prior to substantial completion.

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- E. Include two days on site for TAB efforts as directed in writing by the Owner's Representative after substantial completion.

1.3 STANDARDS AND DEFINITIONS

- A. Perform all work in accordance with these specifications and the latest edition of the NEBB Standards.
- B. Air Handling Unit: Where the term Air Handling Unit (AHU) is used in this spec section, it shall include any factory fabricated or field erected unit that includes a fan and other components which filter, heat, cool, humidify or dehumidify the air stream. But the term AHU, where used in this section, does not include fan powered terminal units, fan coil units, unit heaters, cabinet unit heaters, etc.
- C. Air Handling System: A fan or AHU and ductwork.
- D. Hydronic System: A system in which a liquid is used to convey heat.
- E. Record or Report: Where used as a verb, these terms mean to include in the TAB report.

1.4 QUALIFICATIONS

- A. TAB agencies shall meet the following qualifications:
 - 1. Membership in the Associated Air Balance Council (AABC), National Environmental Balance Bureau (NEBB) or the Testing, Adjusting and Balancing Bureau (TABB).
 - 2. An office located within a 100 mile radius of the project site.
 - 3. A minimum of five (5) years experience in the TAB field.
- B. The following TAB Agencies are prior approved:
NEW MEXICO
 - 1. Energy Balance & Integration
 - 2. Kirk Air Co.
 - a. Native Air
 - b. Demand Test and Balance LLC
 - c. 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.

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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.

PART 2 PRODUCTS

2.1 EQUIPMENT

- A. Provide all equipment and instruments necessary to perform the work specified herein. Calibrate and maintain instruments per NEBB Standards. Provide not less than the following:
1. Pitot tubes and draft gauges.
 2. Flow hood.
 3. Velometer.
 4. Thermometers.
 5. Pressure gauges.
 6. Flow meter test kit.
 7. Ampere – voltmeter.
 8. Speed indicator.
 9. Sound meter to measure eight octave bands.

PART 3 EXECUTION

3.1 GENERAL

- A. Review and inspect the mechanical systems for conformance with design documents. Test, adjust and balance all system flows under design conditions and under other conditions where part load testing is specified. Comply with measurement tolerances per NEBB. Balance to within 10% of design flows unless otherwise specified.
- B. Visually mark the final settings of balancing dampers, balancing valves, fan speed controls, etc.
- C. Comply with NEBB Standards. The descriptions included herein are a guide to the minimum information needed.
- D. Troubleshooting: In the event that any areas fail to get proper flow, take the lead in troubleshooting the system. Measure pressures, flows, etc. at various points throughout the systems as required to identify the cause of the deficiencies and identify upgrades which will resolve these deficiencies. Coordinate any remedial efforts directly with mechanical and controls contractors and re-test as required.

3.2 TEST AND BALANCE REPORT

- A. Report shall be 8-1/2" x 11" bound into a complete and coherent report, except that drawings may be larger size, but still bound into the report. All forms shall be typewritten or legibly handwritten.
- B. Include the following sections in the order indicated:
 - 1. Cover sheet with the Project Name, Location, and the names of the Mechanical Contractor and Engineer
 - 2. Table of Contents
 - 3. Summary indicating the highlights of the report and summarizing any deficiencies and recommendations
 - 4. Test results including the names of the persons performing the tests and dates the tests were performed
 - 5. Drawings
 - 6. Description of the test procedures used
 - 7. List of instruments used along with their calibration data
 - 8. Qualifications of personnel
- C. Submit five copies and a PDF of the complete TAB report minimum two weeks before the first O&M instruction session. One copy will be returned to the Contractor with review comments.

3.3 BASIC AIR HANDLING SYSTEM TESTING, ADJUSTING AND BALANCING

A. General

1. Test all fans and air handling systems. Balance systems to achieve specified air flows while minimizing throttling losses.
2. Air Flow Measurements: Fan and AHU flow rates may be determined by pitot tube traverse or by measuring fan speed, suction and discharge pressures, and comparison with the fan curve. Measure duct air flows using pitot tube traverses. Measure air flows of grilles, registers and diffusers using either capture hoods or pitot tube traverses in the connected ductwork. Make such other tests as may be required to demonstrate that systems perform per the design requirements.
3. Air Flow Measuring Stations: Calibrate each air flow measuring station which is provided as part of the construction contract. Use duct pitot tube traverses or other appropriate means to measure air flows. Coordinate with the flow measuring station supplier, and enter calibration coefficients into the FMS. Record the results of this effort.
4. Alert Mechanical Contractor and Engineer if any fan or air handling unit (AHU) appears to be operating in an improper or unsafe condition.
5. Seal all test holes in ductwork once testing is complete. Repair insulation jackets to maintain the integrity of the vapor barrier.
6. Include in the report copies of ductwork drawings with test points indicated.
7. Variable Flow Systems: Verify proper fan tracking from full flow to 50% flow.

B. Fans: Perform the following for all fans, including those provided as part of an AHU.

1. Fan Nameplate: Record unit number per the equipment schedule, manufacturer, model, size, and serial number.
2. Performance Data: Measure air flow and adjust fan speed to achieve required flow. Record air flow, static pressure rise and fan speed.
 - a. Advise when belt and/or sheave changes are required to achieve the design flows. Mechanical contractor shall make the necessary changes as part of the mechanical contract. Approximately 25% of fans may require a sheave and/or belt change.
3. Current and Voltage: Record motor nameplate and measured voltage and amperage. Advise if motor amps exceed rated load amps.

C. Air Handling Units:

1. Outside Air: Test outside air flows using a pitot tube traverse and balance as required. If a traverse is not practical, use the mixed air temperature method if the inside and outside temperature difference is at least 20 deg F, or use the difference between pitot tube traverses of the supply and return air ducts.
2. Static Pressure: Measure and record the static pressure at the inlet and outlet of each AHU component, including louvers, dampers, filters, coils, etc, and at each inlet and discharge duct connection.

D. Coils: Measure and record air and water flows and pressure drops.

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- E. Air Distribution Systems:
 - 1. Zone, Branch and Main Ducts:
 - a. Adjust to within 10% of design air flows. Balance so that at least one zone balancing damper is wide open. Balance multi-diffuser branch ducts so that at least one outlet or inlet damper is wide open.
 - 2. Air Terminal Units:
 - a. Calibrate flow sensors and enter design maximum and minimum flow setpoints into FMS.
 - b. Record terminal unit number, size, specified flow, agency measured flow, FMS measured flow, and DDC flow correction factors.
 - 3. Diffusers, Registers and Grilles:
 - a. Test, adjust, and balance each diffuser, grille, and register to within 10% of specified design requirements. Record the size of each grille, diffuser, and register, initial flow measurement, and final measured flow.
 - b. Where rooms are indicated to be maintained at either positive or negative pressure, balance air flows to achieve these conditions under design flow conditions, and verify proper pressurization at minimum flow.

- F. Fan Coil Units, Unit Heaters, Cabinet Unit Heaters, Air Curtains, Door Fans, Fan Powered Terminal Units and other devices with fans and coils:
 - 1. For each unit, record unit number, manufacturer, model, size, motor HP, voltage and rated load amps and design air flow.
 - 2. Measure and record initial air flows, along with final air flows, unit inlet and outlet static pressures, voltages, and motor amps.
 - 3. Measure and record initial and final water flows and pressure drops.

- G. Energy Recovery Units:
 - 1. For each unit, record unit number, manufacturer, model, size, motor HP, voltage and rated load amps and design air flow.
 - 2. Measure and record initial air flows, along with final air flows, unit inlet and outlet static pressures, voltages, and motor amps.

- H. Duct Leakage Testing
 - 1. Specification Section 23 3000 describes the requirements for duct leakage testing. Provide all instrumentation and labor to take the required measurements.
 - 2. The Mechanical Contractor shall provide the fans and all other required work.
 - 3. Submit test report. Retest until ductwork complies with specified leakage criteria.

3.4 HYDRONIC SYSTEMS

- A. General:
 - 1. Prior to commencing hydronic balance:

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- 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:

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Eqpt Type		Pumps (Note 1)	Chillers	Air Cooled Condensers	Cooling Towers	Hot Water Boilers	Steam Boilers	Heat Exchangers	Coils			
Tag No.		X	X	X	X	X	X	X	X			
Nameplate Data	Mfgr	X	X	X	X	X	X	X	X			
	Model	X	X	X	X	X	X	X	X			
	Serial	X	X	X	X	X	X	X	X			
	Volts	X	X	X	X	X	X					
	RPM	X	X	X	X	X	X					
	HP	X			X							
	FLA	X	X	X	X	X	X					
	Refrigerant		X	X								
Scheduled	GPM1	X	X		X	X		X	X			
	Press Drop	X	X		X	X		X	X			
	GPM2		X					X				
	Press Drop		X					X				
Measured	GPM1	X	X		X	X		X	X			
	Inlet Press	X	X		X	X		X	X			
	Outlet Press	X	X		X	X		X	X			
	Press Drop	X	X		X	X		X	X			
	GPM2	X	X					X				
	Inlet Press	X	X					X				
	Outlet Press	X	X					X				
	Press Drop	X	X					X				
	Volts	X	X	X	X	X	X					
Amps	X	X	X	X	X	X						

Notes

- 1 For pumps measure pressure rise instead of pressure drop. Measurements for GPM2 shall be at shutoff conditions.
 5. Domestic HW return system: Balance to ensure HW availability throughout the system. Where balancing valves are provided, record flow and balance to provide flow in each circuit.

3.5 LIMIT DEVICES AND SAFETY CONTROLS

- A. Limit Devices: Check all limit devices to verify proper operation, including, freezestats, flow switches, etc. Include in the TAB report a list of all such devices and the results of their tests.
- B. Fire and Smoke Dampers
 - 1. Test each fire damper, smoke damper, and fire/smoke damper to ensure proper operation. Record test results.
 - 2. Fire Dampers: Open access door, disconnect fusible link or activate thermal link, and verify that damper closes smoothly and completely. Reset damper and access door.
 - 3. Smoke Dampers: Open access door, activate damper, observe whether it closes smoothly and completely, and measure closing time. Reset damper and verify it opens completely. Close access door and record test results.
- C. Life Safety Controls: Test and record life safety control operation of the HVAC systems. Verify the installation of required smoke detectors in air handling equipment, and verify operation of the smoke detector by activating the smoke detector and observing air handler shutdown or other required functions as described on the control drawings and sequence of operation. With assistance from the contractors for mechanical, temperature controls and electrical work, verify the operation of interconnected systems, such as the smoke detector's activation of the fire alarm system and the alarm system's activation of the life safety control sequence.

3.6 SOUND TESTING

- A. Measure sound level in approximately ten percent of rooms as directed by Engineer.
 - 1. Shut off mechanical equipment and measure background sound level in each octave band.
 - 2. Start mechanical equipment and measure sound level in each octave band.
 - 3. Submit a plot of measured data against noise criteria (NC) curves.
- B. Where measured sound levels are deemed by Owner to be unacceptable, work with Engineer and Mechanical Contractor to reduce actual levels, and retest as required.

3.7 AIR HANDLING SYSTEMS – SPECIAL APPLICATIONS

- A. Rooms Requiring Air Flow Tracking and/or Active Room Pressure Control:
 - 1. Calibrate flow sensors for all supply and exhaust air devices serving the room, and enter design maximum and minimum flow setpoints into FMS.
 - 2. Calibrate room pressure sensor.
 - 3. Verify proper air flow tracking and room pressure control as the system operates from maximum to minimum, and back to maximum flow.

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4. Submit a separate sheet in the report for each such room. Include an air flow diagram showing each device in the air flow and control system, and record all pertinent design and measured data on this sheet, including but not limited to:
 - a. Air valves: Tag number, size, specified flow, agency measured flows and FMS measured flows at various flow conditions, and DDC flow correction factors.
 - b. Offset air flows and room pressures at various flow conditions.
- B. Rooms to be Balanced to a Positive or Negative Pressure (Without the Use of Air Flow Tracking or Active Pressure Controls):
 1. Balance supply and return air flows as required
 2. Crack open the door and use a smoke puffer to demonstrate the direction of air flow. Test under maximum and minimum flows. Record test results.
- C. Room Tightness Testing:
 1. Where a room tightness test is specified, provide the instrumentation and labor to perform such test.
 2. The Mechanical Contractor shall provide the fans and associated ductwork for the test.
 3. Submit test report. Retest until room complies with room leakage criteria.
- D. Fume Hoods and Biological Safety Cabinets: Test exhaust airflow by duct pitot tube traverse, and adjust exhaust air valve to control to within 5% of design flow. Balance makeup air flows as specified above. Test for turbulence and proper air flow patterns at the face and inside hoods using a smoke puffer or other approved smoke-emitting device. Document the test results, and advise of any concerns and recommendations.
- E. Building/Zone Pressurization: Test and adjust building/zone pressurization by setting the design flows to meet the required flow direction and pressure differential. For positive pressure areas, set the supply air to design flow, and gradually reduce the exhaust air rate to obtain the required flow or pressure difference. For negative pressure areas, set the supply air to design flow, and gradually increase the exhaust air rate to obtain the required flow or pressure difference.

END OF SECTION

SECTION 23 0700 MECHANICAL SYSTEMS INSULATION

PART 1 GENERAL

1.1 REQUIREMENTS

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

1.2 RELATED SECTIONS

- A. Section 23 0500, Common Work Requirements for HVAC.
- B. Section 23 0504, Pipe and Pipe Fittings.
- C. Section 23 3000, Air Tempering System and Equipment.

1.3 SCOPE

- A. Field insulation of piping: see drawings and Part 3 of this specification.
- B. Field insulation of ductwork: See drawings, Table 23 0700-1, and Part 3 of this specification.
- C. Field insulation of equipment supplied and/or installed under Division 23: See drawings and Part 3 of this specification.
- D. Factory-insulated equipment and materials are described on the equipment schedule, on the drawings, and in other sections of this specification.

1.4 SUBMITTALS

- A. Submit products to be used including insulation, jackets, miscellaneous products, and products for special applications. Review each application and advise if any product is either not suitable for, or not recommended for the application.
- B. Verify that each submitted product meets all requirements for that product as specified herein. Include literature that clearly shows products meet all aspects of the spec. Include a cover sheet or letter with the following statement:
 - “Each product submitted here meets all specified requirements for that product except as follows:” followed by a list of any discrepancies.
- C. Submit schedules showing the type of product and thickness for each application. Indicate products to be used on valves and fittings. Indicate where vapor barriers will be provided and what jackets will be used.

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- D. D-5, D-6 & D-7 insulation: If one of these insulations is specified, submit documentation indicating that the submitted materials are approved for the intended service.
- E. Submit a description of the application techniques to be used.

1.5 QUALITY ASSURANCE

- A. Comply with the latest edition of the National Commercial & Industrial Insulation Standards, as published by the Midwest Insulation Contractors Association.
- B. Part 3 and Table 23 0700-1 give the system temperatures for various applications. Supplier shall review these temperatures and confirm the suitability of all components for the specified applications.
- C. Test piping and ductwork in accordance with applicable specification sections before insulation is applied.

PART 2 PRODUCTS

2.1 GENERAL

- A. All materials must be 100% asbestos-free and 100% formaldehyde-free, NO EXCEPTION.
- B. All materials must be GreenGuard Gold Certified.
- C. Smoke and Fire Ratings: All materials shall have a composite fire and smoke hazard rating not exceeding flame spread 25, fuel contribution 50, smoke developed 50, when tested as assemblies per ASTM Standard E-84 or NFPA 255.
- D. Thermal conductivities: Per ASTM C518. Do not exceed the conductivities indicated. Units listed herein for conductivity are Btuh-in/SF-F. Resistance shall not be less than the values specified herein. Units for resistance are SF-F/Btuh.
- E. Noise Reduction Coefficients: Per ASTM C423 based on Type A mounting. NRC shall not be less than as specified.
- F. Jackets: Maximum 0.02 perm water vapor transmission per ASTM E96 Procedure A.
 - 1. ASJ: All service jacket per ASTM C1136 Type I, paintable white kraft paper outer surface reinforced with glass fiber yarn and bonded to aluminum foil, with self-sealing longitudinal lap and butt strips, breach puncture min. 50 oz-in/in tear per ASTM D781, tensile strength min. 30 lb/in per ASTM D828.
 - 2. FSK: Foil skim kraft per ASTM C1136 Type II.
- G. Fiberglass insulation: Inorganic fibers bonded with thermosetting resin.

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- H. Approved Manufacturers: Owens Corning, Johns Manville, Knauf, Certain-Teed, Kflex, Armacell, Unifrax - Insulfrax, Industrial Insulation Group, Pittsburgh Corning. Where the term OAE is used herein, this refers to these manufacturers only. No other manufacturers are approved for this project.

2.2 PIPE INSULATION

A. General

1. Valves, Fittings, and Accessories: Use the same insulation materials and thickness as the pipe insulation, except as noted.

- B. Type P-1, Fiberglass Pipe Insulation: Factory assembled insulation and ASJ. Pre-formed fiberglass per ASTM C547 Type I, suitable for use on surfaces from 0–850°F, with thermal conductivity 0.23 at 75°F or 0.33 at 250°F, and minimum 3 pcf density. ASJ shall have self-sealing lap at end and along length, with pressure sensitive tape lap sealing system. Owens Corning SSL II Pipe Insulation, Johns Manville Micro-Lok, Knauf Pipe Insulation.

1. Where Type P-1 insulation is used, insulate fittings, valves and accessories using one of the following:
 - a. Fiberglass pre-formed fitting insulation complying with the specification for P-1 pipe insulation, Johns Manville Hi-Lo Temp insulation inserts, Hamfab, OAE. Finish with Type J-2 fitting covers.
 - b. Where pre-formed fitting insulation is not available, the following may be used: minimum 0.75 pcf density fiberglass per spec for D-1 insulation except without FSK. Finish with Type J-2 fitting covers or with two coats of fitting mastic with fiberglass fitting tape embedded between coats.

- C. Type P-2, Fiberglass Pipe and Tank Insulation: Similar to Type P-1 insulation and jacket, except with fibers oriented to allow insulation to be wrapped onto curved surfaces, with conductivity 0.30 at 100°F, or 0.55 at 400°F. Johns Manville Pipe & Tank Insulation, Owens Corning Pipe and Tank Insulation or Knauf Pipe and Tank Insulation.

1. Alternate: Fiberglass board insulation similar to Type D2, scored for application on curved surfaces, with ASJ.

- D. Type P-3, Calcium Silicate Pipe Insulation: Rigid calcium silicate per ASTM C533, Type 1, asbestos-free, suitable for use on piping up to 1200°F, conductivity 0.55 at 700°F, compressive strength min. 200 psi at 5% compression. Industrial Insulation Group OAE.

1. Fittings, valves and accessories: Insulate with mitered Type P-3 insulation or Type D-7 insulation.

- E. Type P-4, Elastomeric Foam Pipe Insulation: Pre-formed elastomeric foam, ASTM C534 Type 1 flexible, closed cell, suitable for use up to 220°F, UV protected, not to exceed flame spread 25 and smoke developed 50 based on 0.75-inch thickness, conductivity 0.30 at 75°F. Kflex, Armacell OAE.

1. Fittings, valves and accessories: Insulate using either Type P-4 insulation pre-formed for use on fittings and valves, or cut sections of P-4 pipe insulation to match the shape of the fitting or valve, taped on using PVC tape.

2.3 DUCTWORK INSULATION

- A. Type D-1, Fiberglass Blanket: Factory fabricated insulation and FSK jacket assembly suitable for applications from 40-250°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.

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- H. Type D-8 – Polystyrene Insulation: Rigid cellular square edge insulation per ASTM C578, waterproof, thermal conductivity 0.20, compressive strength 25 psi. Dow Styrofoam or Owens Corning Foamular.
- I. Type D-9 – Fiberglass Ductboard: Listed per UL 181 as a Class 1 Rigid Air Duct; conforming to ASHRAE Std. 62, NFPA-90A and 90B, ASTM G-21 & G-22; rated for 2-in. wg; constructed of fiberglass bonded with a thermosetting resin, with double density slip joints pre-molded in the board; FSK jacket; thermosetting acrylic polymer interior surface, and black interior surface color. Thermal conductivity 0.23, and NRC 0.70 at 1-inch thick and 1.0 at 2-inch thick. Johns Manville Superduct 475 or 800, Owens Corning Quiet R Duct Board, Knauf Duct Board M, Certainteed ToughGard Duct Board

2.4 EQUIPMENT INSULATION

- A. E-1, Removable Insulating Blanket: Factory fabricated, one-piece, removable and re-usable insulating blanket with fiberglass insulation completely enclosed within a silicone coated fiberglass cloth with draw cords of SS or PTFE coated glass fiber, and stainless steel clips. Insulation thickness shall be as specified elsewhere, but not less than 1-inch. Energy Systems Inc. “Q-Master” OAE.

2.5 INSULATION JACKETS

- A. Type J-1, Metal Jacket: 0.010-inch smooth Type 304 stainless steel or 0.016-inch smooth or embossed aluminum per ASTM B-209, with minimum 1-mil polyethylene film with protective layer of 40 Lb virgin kraft paper, continuously laminated to full width inside jacket. Childers OAE.
 - 1. Where jacket diameter is 16–96 in: 0.016-in. SS or 0.020 in. aluminum.
 - 2. Equipment heads and all surfaces where jacket is greater than 96-inch OD: 0.020-inch SS or 0.024 inch aluminum.
 - 3. Fittings and Accessories: Provide the same jacket material as for pipe.
- B. Type J-2, PVC Jacket: Minimum 20 mil sheets and 30-mil pre-molded fitting covers, ASTM D1784, Class 16354-C. Accessories include solvent weld solution, stainless steel tacks, and tape. All components shall be white, UV resistant, with paintable exterior surface, and suitable for use at –20 to +150°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.

2.6 MISCELLANEOUS PRODUCTS

- A. General:
 - 1. Tapes: Aluminum, pressure sensitive, UL 181A-P listed and embossed, minimum 2.5-inch wide, Nashua 324A OAE.
 - 2. Duct Liner Adhesives: Water-based, complying with ASTM C916.

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3. Solvent Cement for PVC Jackets: Johns Manville Perma-Weld OAE.
 4. Staples: Outward clinching, 0.5-inch galvanized steel
- B. Piping Systems:
1. Pipe Hanger Insulation Inserts: Mechanical Pipe Shields Inc. "Snapp Itz" OAE.
- C. Ductwork Systems:
1. Duct Liner Edge Sealer, Surface Sealer, Coatings & Adhesives: To meet ASTM C916. Johns Manville Superseal OAE.

2.7 SPECIAL APPLICATIONS

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

PART 3 EXECUTION

3.1 GENERAL

- A. Delivery, Storage and Handling: Deliver and store insulation materials in factory-supplied containers. Protect from moisture. Do not install any materials that have gotten wet, regardless whether they are subsequently dried.
- B. Store and apply materials in accordance with manufacturers' recommendations, but not less than the following minimum temperatures. Ensure surfaces are clean and dry prior to application, and for minimum two hours after application:
1. Sealers, coatings, solvents and adhesives: 40°F.
 2. Tapes 50°F.
- C. Install in accordance with manufacturer's recommendations, NAIMA recommendations, and this spec. Provide good ventilation.
- D. Where vapor barriers are specified, ensure that the entire system is vapor sealed.
- E. Protect materials from water damage. Replace any materials that are water-damaged prior to substantial completion.

3.2 PIPING INSULATION

- A. General: Insulate piping as indicated herein and/or on the drawings. Except as noted, insulate all valves, fittings, and accessories with the same material and thickness specified for the pipe. Where piping is specified with a separate insulation jacket provide this same jacket for valves, fittings and accessories. Vapor seal cold piping systems.
1. Where insulation terminates, provide insulating cement beveled for a neat finish. For vaporsealed piping, coat with insulating mastic prior to applying insulating cement.

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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: Chilled water, refrigerant suction, condenser water (outdoor piping subject to freezing).
2. Temperature Range TR-2: Domestic cold water, makeup water, soft water, industrial water, process water of any type, non-potable water, HVAC make-up water (except insulation is not required for evap cooler makeup piping outdoors), interior horizontal roof drain and overflow bowls and piping, condensate drains indoors.
3. Temperature Range TR-3: Domestic hot water (including non-circulating HW within interior walls and chases) and domestic HW return except as noted.

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4. Temperature Range TR-4: Heating water supply and return, low pressure steam condensate, pumped condensate return, engine cooling water.
- C. Special Applications
 1. Handicap Lavatories: Insulate domestic hot and cold water piping and P-traps exposed below handicapped lavatories with insulation kit specifically designed for the application.
- 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

3.3 DUCTWORK INSULATION

- A. General:
 1. Insulate all ducts except those specified to be uninsulated. The following ductwork need not be field insulated:
 - a. Factory insulated ductwork and plenums.
 - b. Ducts with acoustic lining, provided the lining thickness matches or exceeds the required insulation thickness.
 - c. Exhaust ducts, except where noted.
 - d. Return air ducts, except where noted.
 2. See Table 23 0700-1 for additional information.
 3. Ensure that ductwork is leakage tested prior to applying insulation. Inspect ductwork and repair any deficiencies prior to applying insulation. Do not apply insulation over deficient ductwork or plenum construction.
 4. Ensure that ductwork is clean and dry before applying insulation.
 5. For ductwork with acoustic lining the drawings indicate the "clear inside duct dimension" required. Over-size ducts as required to provide the required air flow area.
- B. Type D-1, Fiberglass Blanket Insulation: Measure and cut insulation. Install so insulation is not excessively compressed at corners. For rectangular and flat oval ducts 24-inches and wider,

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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 indicated. Comply with the NAIMA Fibrous Glass Duct Liner Standard (FGDLS), manufacturer's recommendations, and this spec. Adhere liner with minimum 90% coverage of adhesive, and secure with mechanical fasteners and washers per FGDLS and manufacturer's recommendations. Fastener length shall be sufficient to limit compression of liner to 1/8" maximum. Coat all cut edges and surface penetrations with edge sealer. Provide metal nosing for liner leading edges at fan discharge and for all ducts with air velocities exceeding 3,000 FPM. Maintain minimum 18-inch clearance from electric resistance heaters. Interrupt liner at dampers and apply external insulation at these locations.
 - 1. Provide Type D-3 insulation for the 10 feet upstream of roof exhaust fans except in wet air streams.
- E. Type D-5: Install insulation in a 2-layer system per manufacturer's instructions, including the use of mechanical fasteners for the underside of ducts, butting or overlapping of joints, and offsetting of joints on outer layer.
- F. Type D-6: Install in accordance with manufacturer's instructions. Overlap seams and joints minimum 2-inches, affix with SS wire minimum 18-inches on centers, but not less than per manufacturer's recommendations, and tape seams and joints with aluminum tape.
- G. Type D-7: Install insulation in a single-layer system per manufacturer's instructions. Mechanical fasteners for the underside of ducts shall be adhered to the duct in a manner suitable for the operating temperatures (welded or other suitable method). Butt or overlap joints per manufacturer's recommendations.
- H. Type D-8: Wire in place with SS wire minimum 12-inches on centers, and provide J-1 jacket.
- I. Type D-9: Install per manufacturer's recommendations, NAIMA standards, and SMACNA Fibrous Glass Duct Construction Standards. Provide ship lap seams and joints.

3.4 EQUIPMENT INSULATION

- A. General: Where specified elsewhere, equipment will be factory insulated. Insulate all equipment as noted herein except portions of equipment that are factory insulated.

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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. HW Pumps: Do not insulate.

3.5 JACKETING

- A. Type J-1, Metal Jacketing:
1. Ducts: Slope jacketing to shed rain.
 2. Pipes: Install with seams at the 3 o'clock or 9 o'clock position to shed water. Band 12" on centers.
 3. Joints and Seams: Overlap joints minimum 2-inches. Caulk with a weatherproof caulk when located outdoors.
- B. Type J-2, PVC Jacketing: Secure in place with tacks and solvent welded joints. White PVC tape may be used indoors.
- C. Type J-3, Canvas Jacket: Apply mastic at a rate of 60 to 70 sq. ft. per gallon, embed fiberglass mesh, smooth all wrinkles and apply finish coat of Sealfas, or equivalent.

END OF SECTION

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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 23 3000 AIR TEMPERING SYSTEM AND EQUIPMENT

PART 1 GENERAL

1.1 REQUIREMENTS

- A. Provide all products, labor and services necessary to construct and demonstrate proper functionality of the HVAC and exhaust systems indicated on the drawings and specified herein.
- B. Conform with applicable provisions of the General Conditions, the Supplemental General Conditions and General Requirements.
- C. See Sections 23 0500, 23 0548, 23 0549, 23 0593, 23 0700, and 23 0900 for additional requirements.
- D. Comply with the Equipment General Requirements in Spec Section 23 0500.

1.2 SCOPE

- A. Install control dampers supplied under Section 23 0900. Adjust dampers for smooth operation.
- B. Equipment provided by others: Provide ductwork to serve equipment provided by others, including fume hoods, etc, where that equipment requires ducted supply or exhaust.

1.3 SUBMITTALS

- A. Submit the following for review and approval:
 - 1. All equipment shown on the equipment schedule and elsewhere on the drawings. Submit evidence or certification that equipment complies with ASHRAE Std. 90.1.
 - 2. Ductwork construction standards, sheet metal, plenums, ductwork accessories, etc.
 - 3. Flues and vents: Materials of construction and accessories. For vents with horizontal offsets or expansion joints, submit layout for review.
 - 4. Dampers for fire and smoke control: For each type of damper proposed, submit manufacturer's literature demonstrating compliance with all aspects of the specifications and drawings. Submit manufacturer's installation instructions.
 - 5. Air Filters and Filter Gauges
 - 6. Grilles, Registers & Diffusers: Configuration, materials of construction, finish, mounting details, and performance data including throw, static-pressure drop, and noise ratings. Submit for type only, but supplier shall check and verify that the indicated diffuser type and sizing are appropriate for each area. Advise of any concerns in any areas.

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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 2015 Chapter 6 – Duct Systems
 2. UMC 2015 Standard 6-2, Standard for Metal Ducts
 3. SMACNA 2005 HVAC Duct Construction Standards – Metal and Flexible, including Addendums
 4. SMACNA Round Industrial Duct Construction Standards – 1999
 5. SMACNA Rectangular Industrial Duct Construction Standards – 2004
 6. NFPA-90A-2002 - Standard for the Installation of Air-Conditioning and Ventilating Systems
- B. Component Characteristics
 1. All components within ducts and plenums shall be non-combustible or shall have a flame spread less than 25 and smoke developed less than 50 when tested as a composite product per NFPA 255, ASTM E84, or UL 723, except where specifically permitted by the UMC and noted in the drawings or specs.

1.5 SOUND LEVELS

- A. Sound levels attributable to mechanical equipment are designed to result in sound levels of NC 40 for offices, conference rooms, and NC 35 for classrooms, etc., measured within the rooms. Mechanical equipment that has been substituted for the specified equipment shall perform within the specified equipment sound limitations, or will be replaced or adjusted as required. Sound levels attributable to duct vibration that result in noticeable noise or vibration to duct hangers, lighting fixtures, ceiling tees or diffusers shall be re-supported or adjusted until the disturbing noise is brought within acceptable limits.

1.6 DIMENSIONS

- A. Compare all drawings and verify all dimensions both on the drawings and in the field before laying-out, cutting, and fabricating the work.
- B. Refer to Section 23 0500, Common Work Requirements for HVAC, for coordination drawing requirements.

PART 2 PRODUCTS

2.1 DUCTWORK AND PLENUMS

- A. Materials: Construct all ducts, casings, plenums etc. from galvanized steel sheets except as indicated. Sheets shall be free of blisters, slivers, pits, and imperfectly galvanized spots. Reinforcing angles and bars, and duct support materials shall be same material as ductwork if exposed to the air stream, or galvanized steel if not exposed to the air stream.
 - 1. Galvanized Steel: Per ASTM A653/A653M Standard Specification for Steel Sheet, Zinc-Coat (Galvanized) by the Hot Dip Process G90 coating designation.
 - 2. Aluminum: Alloy 3003-H14
 - 3. Stainless Steel: 340SS, provide No. 2B finish in exposed areas
 - 4. Fiberglass Ductwork (Ductboard): Use only where specifically noted. Minimum 1-inch thick, 3 lb. density rigid fiberglass ductboard with glass fiber reinforced vapor barrier, UL Class 1, labeled on each board per UMC-06 Standard 6-5.
 - a. Properties:
 - 1) Thermal conductivity for 1-inch thickness shall not exceed 0.22 Btuh/SF-F at 75 deg F
 - 2) Noise reduction coefficient of 0.80 on Mounting No. 6.
 - b. Tape: 3-inch "Hardcast" mineral impregnated woven fiber tape with an actuator/adhesive applied in accordance with the manufacturer's directions, or thermlok heat sensitive tapes. Pressure sensitive tapes will not be accepted.
 - c. Owens-Corning Fiberglass, Johns Manville, Certain-Teed or equivalent. Flexural rigidity (E.I.) average shall not be less than 475.
 - 5. Polyvinyl Coated Galvanized Steel: Minimum 4 mil polyvinyl coating. Foremost Manufacturing Company, Southfield, Michigan. Model PCD 4 by 1 for exterior coating only, or Model PCD 4 by 4 for both interior and exterior coating.
- B. Flexible Ducts: Factory fabricated, listed as a Class 1 Air Duct per UL 181 with aluminum foil interior liner, corrosion resistant helix mechanically locked to fabric to ensure dimensional stability, helix separated from air stream, R-5 fiberglass insulation, and metalized outer vapor barrier. Ducts shall be rated at 10-inch positive pressure, 5-inch negative pressure, 0.1 perm per ASTM E96, and -20 to +250°F. Flexmaster Type 3M, Thermaflex M-KC, OAE.

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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.

2.2 SHEET METAL ACCESSORIES

- A. Dampers: Factory fabricated, suitable for use with air at -20 to +240°F, galvanized steel housing and blades except as noted, rated for indicated pressures in either direction and performance rated per AMCA-500.
1. Shafts: Square or hexagonal steel, 3/8-inch or 1/2-inch, continuous through damper, mechanically fastened to damper blade, and extending through frame as required for actuator or standoff bracket and locking quadrant as required by table below.
 2. Bearings: Provide for each side of each shaft, molded synthetic or stainless steel sleeve type.
 3. Multi-blade dampers: Except as indicated, provide parallel-blade for 2-position applications and opposed blade for modulating applications. Provide jackshafts as required to drive large dampers.
 4. Air pressure drop shall not exceed:
 - a. Dampers rated at 1500 FPM: ____ in wg at 1500 FPM
 - b. Dampers rated at 4000 FPM: ____ in. wg at 4000 FPM
 5. The dampers described in this section are assigned Type Numbers D1 through D23. The following table summarizes key characteristics of each type of damper. Drawings and Part 3 – Execution, indicate which type of damper to use in each application.

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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

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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 cross-section, 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; sound 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 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.
1. Roof Curbs: 1.5-inch fiberglass insulation with nominal 2" x 2" wood nailer. Provide damper tray where a damper is indicated. Thycurb TC, Greenheck, OAE.
 2. Equipment Support Rails: Nominal 2" x 4" wood nailer. Thycurb TEMS, Greenheck OAE
- F. Louvers: 4-inch extruded 6063-T5 aluminum alloy frame and blades with flange, mill finish, and 1/2-inch galvanized steel bird screen.
1. Structural: Designed and furnished to carry wind load of not less than 20 psf. Intermediate mullions and supports if provided as part of louver, shall not be visible from the exterior.
 2. Air Pressure Drop: Less than 0.20 in wg at 1000 FPM over free area (8.58 square feet), intake or exhaust per AMCA 500 based on 48 x 48 test sample.
 3. Moisture Penetration: Less than 0.01 oz/sf over 15 minute test per AMCA-500 at 873 FPM intake over free area based on 48 x 48 test sample.
 4. Ruskin ELF375DX OAE.
- G. Acoustic Louvers
1. Ruskin ACL 1245, 12 inches deep, with 45 degree blade angle, 22 percent free area (48"

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x 48" typical unit with .15 inch w.g. maximum pressure drop, at 4277 cfm air flow). Frame and blade material shall be galvanized steel. Free field noise reduction shall be:

Band Frequency (Hz)	63	125	250	500	1000	2000	4000	8000
Reduction (db)	14	13	15	20	23	22	20	20

2. Provide bird-screen, steel channel frame, Ruskatherm blanket insulation, and perforated steel interior surface that covers insulation.

H. Thermometers: As specified in Section 23 0505.

I. Barometric Pressure Balance Dampers: Air Balance, Inc. units with adjustable counter weight, aluminum air foil design blades, nylon bearings. Match frame assembly to wall or duct.

2.3 FLUES AND VENTS FOR FUEL-FIRED EQUIPMENT

A. General: Factory-built metallic vent system, UL Listed components. Each component shall bear indication of its UL listing.

1. Heat Resistant Paint: Glidden, Metallite OAE.
2. Approved Vent Manufacturers: Metal Fab, Metalbestos, Schebler, Ampco, OAE.

B. Type B Vent: Listed per UL 441 for use with UL Listed Category I (gas or propane fired, negative pressure, non-condensing) appliances to 530° F, round or flat oval as indicated, double wall with aluminum alloy inner wall, galvanized steel outer wall, both walls hemmed to eliminate sharp edges, minimum 1/4-inch air space for sizes 6-inches and smaller and minimum 1/2-inch air space for sizes 7-inches and larger, with guides to maintain air space. Provide UL Listed vent cap. Metal Fab Type M.

1. Barometric Draft Regulator: UL Listed, double acting type.

C. Type III Vent: For use with Category III appliances or other positive pressure, non-condensing appliances including oil-fired or solid-fuel equipment not exceeding 1200° F exhaust temperature. Listed per UL-103 for use with gas, liquid or solid fuels per NFPA-211 which produce gases up to 1400° F continuously and 1800°F intermittently. Double wall with spacers to maintain alignment, rated for 10-inch clearance to combustibles, 4-inch clearance to noncombustibles, and zero clearance to fire-rated or non-combustible chase.

1. Inner Pipe: Connected with V-bands of same material as inner pipe, and sealed with silicone sealant appropriate for the exhaust gas temperature. Pressure tight to 60 inches water.
2. Outer Pipe: Seal with V-band of same material as outer pipe. Provide silicone sealant for portions exposed outdoors.
3. Expansion Joints: Bellows type.
4. Options and Accessories:
 - a. Inner Wall: 304 SS
 - b. Outer Wall: 304 SS.
 - 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 Ludlum, 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: 304 SS.
 4. Metal Fab Type CG

2.4 DAMPERS FOR FIRE AND SMOKE CONTROL

- A. General: Factory assembled and UL listed as an assembly, suitable for horizontal or vertical air flow and for ducted or un-ducted applications. Fire dampers (FDs) shall be listed per UL 555, smoke dampers (SMDs) shall be listed per UL 555S, and fire/smoke dampers (FSDs) shall be listed per UL 555 and UL 555S. Units shall be galvanized steel except as noted. Approved manufacturers: Greenheck, Ruskin, Potorff, or approved equal.
- B. Combination Fire/Smoke Dampers: Factory assembled complete with damper, actuator, thermal link, and all specified accessories, all mounted on a sleeve.
1. Construction: Round blades, rectangular parallel blades and rectangular opposed blades are acceptable, except dampers shall be rectangular opposed blade type when installed in any of the following conditions: within 10 diameters of a fan or supply register, within 3 diameters of an elbow. Internal frames in rectangular FSDs shall be low profile type for ducts 17”H and less.
 2. All components factory installed and wired, including actuator, thermal link, position switches, temperature over-ride (if specified), test switch (if specified), etc. Mount all such components on outside of FSD sleeve to the side of duct (not top or bottom) except where indicated or approved. FSDs must be suitable for rotating the unit 180-degrees so these components can be on either side of the duct.
 3. Air pressure drops shall be certified per AMCA 500D. Pressure loss coefficient C_o shall not exceed the following when tested per AMCA Figure 5.3:

<u>Size (in)</u>	<u>3-V Blade</u>	<u>Airfoil Blade</u>	<u>Round</u>
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

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4. Listed for installation within wall, floor or ceiling assemblies as indicated on drawings.
 - a. Ratings, except as noted: 1.5-hr Fire Rated, Leakage Class 1, 350°F, 4-inch Static Pressure, Dynamic.
 - 1) Up to 1600 FPM: Greenheck FSD-211 (3-V blade type), OFSD-211, or FSDR-511 (round).
 - 2) Up to 3000 FPM: Greenheck FSD-311 or 311V (airfoil blade) or OFSD-311.
 - b. 3-Hr Rated Walls: Greenheck FSD-231.
 - c. Stainless Steel: Greenheck SSFSD-211 or SSFSDR-511 (round).
 5. Actuators: Electric 2-position, 115/1/60 (provide factory wired transformer if required), normally closed, spring return, NEMA-1 except as noted. Actuator shall fully re-open damper when power is restored after any power interruption.
 6. Accessories
 - a. Transitions: Provide round-to-rectangular, oval-to-rectangular, or rectangular-to-rectangular transitions as appropriate for the application.
 - b. Thermal Link: Provide re-settable bi-metallic thermal link to initiate closure when the air temperature within the duct rises to 165° F. Where indicated provide thermal links for operation at 212° F, 250° F, or 350° F. Thermal link shall be easily resettable from outside the duct.
 - c. Position Switches: Provide dry contacts for remote monitoring of damper open and closed positions.
 - d. Retaining plates and angles: Provide as required. Galvanized steel specifically designed for the particular FSD and included as part of the UL Listed assembly.
 - e. Installation decals: Provide installation decals on the sleeve which give the installer clear installation instructions.
 - f. Temperature Override Control: Provide controls so that the thermal link can be over-ridden and the FSD opened for smoke control, even if the air temperature exceeds the setting of the thermal link, provided the temperature does not exceed 350° F.
- C. Smoke dampers: Similar to fire/smoke dampers noted above, except as follows:
1. Smoke dampers shall comply with UL 555S, but need not comply with UL 555.
 2. Smoke dampers need not have a fire rating.
 3. The thermal link and temperature override are not applicable.
 4. Suitable for installation within a wall, floor or ceiling assemblies as indicated.
 - a. Ratings, except as noted: Leakage Class 1, 350° F, 4-inch Static Pressure, Dynamic.
 - 1) Up to 1600 FPM: Greenheck SMD-201 (3-V blade type) or SMDR-501 (round).
 - 2) Up to 3000 FPM: Greenheck SMD-301, 301V (airfoil blade) or SMDR-401.
 - b. 6-inch pressure rated: Similar to Greenheck SMD-401

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c. Stainless Steel: SSSMD-201 & SSSMDR-501 (round).

- D. Fire Dampers: Dynamic rated, suitable for closing against 8-inch differential pressure. Curtain type with sleeve and 165°F replaceable fusible link, resettable. Provide round-to-rectangular, oval-to-rectangular, or rectangular-to-rectangular transitions as appropriate.
1. 1.5-hr rated: Greenheck DFD-155
 2. 3-hr Rated: Greenheck DFD-355.
 3. Provide 212° F fusible links for high temperature applications.
- E. Ceiling Radiation Dampers: UL Classified for use with fire rated floor/ceiling assemblies, with 165°F fusible link replaceable through the damper assembly, 1.5-hr rated except as noted. Greenheck CRD-1, CRD-2 (round), CRD-60, or CRD-60X. Provide 212° F fusible link and 3-hr rated dampers where indicated.

2.5 FILTERS AND FILTER GAUGES

- A. Rated per ASHRAE Std. 52.1; Class 1 or 2 per UL Std. 900; glass fiber media; suitable for operation from -20° F to +170° F; corrosion resistant; suitable for installation with pleats either horizontal or vertical, and for air flow horizontal, vertical upflow, or vertical downflow; suitable for face velocity up to 625 FPM. Unless specified elsewhere, pre-filters shall be MERV-7, and final filters (where specified) shall be MERV-14. AAF, Camfil Farr, or approved equal.

		MERV RATING						
		7	11	14	11	14	11	14
Description								High Capacity
Configuration		2-inch or 4-inch	12-inch Cartridge		6-inch Cartridge		12-inch Cartridge	
Initial Resistance	in. wg.	0.26	0.25	0.58	0.39	0.58	0.29	0.49
Rated Velocity	FPM	500	500	500	500	500	500	500
Max Velocity	FPM	625	625	625	625	625	750	750
Recommended Final Resistance	in. wg.	0.7	1.5	1.5	1.5	1.5	1.5	1.5
Gross Media per 24 x 24 Filter	SF	14 Pleats per foot	62	62	105	125	175	175
Housing		Cardboard	Polystyrene or Aluminized Steel	Polystyrene or Aluminized Steel	Polystyrene or Aluminized Steel			

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Frame		Channel	Gasketed	Gasketed	Gasketed
AAF Model		Perfect Pleat	VariCel RF	VariCel M-Pak	VariCel V
Camfil Farr Model		3030	RigaFlow		

- B. Filter Gauges: Provide a filter gauge for each bank of filters. Gauges shall be magnehelic type with static pressure taps and inter-connecting piping. Ranges shall be 0-1 inch w.g. for all filters except bag filters which shall have a range of 0-2 inches w.g.

2.6 TERMINAL UNITS

- A. General: Factory packaged unit with casing, air valve, air flow sensor. If the following sections are specified or required, provide them as part of the factory package: heating section, fan, and sound attenuator. Terminal units (TUs) shall be suitable for variable volume operation over the scheduled air flow ranges. Air flow and sound performance shall be rated per ARI 880. All materials in the air stream shall comply with the requirements of UL-181 and NFPA-90A.

1. Unit Construction:

- a. Casing: Minimum 22-gauge galvanized steel with round inlet collar, rectangular outlet collar, 3/4-inch acoustic lining with cut edges coated with sealant.
- b. Air Valve: Heavy gauge metal damper, shaft to extend through casing, self-lubricating bearing, with leakage not to exceed 2% of rated air flow when closed with 3-inch inlet pressure.
- c. Air Flow Sensor: Cross configuration located at inlet of assembly, accurate to within 5% with 90° elbow directly at inlet connection. Provide
- d. Sound Attenuator: Galvanized steel with acoustic lining. Provide aluminum liner if specified for casing.
- e. Heating Section:
 - 1) HW Coils: Copper tubes, aluminum fins, galvanized steel casing, sweat connections, ARI rated, minimum 300 psi rated. Size heating coils for the capacities indicated on the equipment schedule. Provide single row coils wherever they can do the specified heating duty. Provide 2-row coils where indicated and where required for the indicated heating capacity. Do not exceed 0.5-inch static pressure drop for the entire unit (terminal unit, heating coil and sound attenuator). Where necessary to limit pressure drop, either over-size unit or provide a separate, larger (lower pressure drop) heating coil to be installed in the discharge ductwork.
 - 2) Electric Heaters: Factory installed and wired with all necessary safety controls, UL listed as an assembly, with galvanized steel enclosure, 80/20 nickel chrome heater elements, electronic modulating control with 4-20 mA input signal from DDC system, air flow switch, access door with door interlock disconnect switch, automatic reset primary thermal cutout switch, manual reset secondary thermal cutout, 24-V control transformer, NEMA-1 enclosure for all electrical components with hinged access door with wiring diagram. Controller shall be solid state type to minimize electrical interference and for silent operation.

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2. Sound Data: The equipment schedules show maximum allowable NC levels based on unit sound power measured per ARI-885, and sound attenuation per ARI-885 Appendix E with a Type 2 ceiling. Do not exceed the scheduled sound levels.
 3. Controls: Controls will be supplied by the controls contractor for installation by terminal unit (TU) supplier. Coordinate with controls contractor who will ship controls to TU manufacturer. TU manufacturer shall install controls onto terminal units.
 4. Approved Manufacturers: Price, Anemostat, Titus, Krueger, or approved equal.
- B. VAV Reheat: Single duct type with reheat as indicated, Price SDV.
- C. Fan Powered: Parallel flow type with backdraft damper at fan discharge. Electric heating coil may be in total air stream, but HW coil must be in secondary air section. Capable of providing heating to space with primary air system shut down. Provide collar to allow ducting the secondary air inlet. Price FDV or approved equal.
1. Fan: Forward curved, steel, dynamically balanced, direct drive, ECM motor with permanently lubricated bearings and thermal overloads.
 2. Electrical:
- D. Dual Duct: With separate air flow sensor and air valve for hot and cold air streams, and air flow sensor in the mixed outlet air stream, suitable for variable volume operation, Price DDQ.

2.7 GRILLES, REGISTERS AND DIFFUSERS

- A. General: Performance rated per ASHRAE Std 70, *Method of Testing for Rating the Performance of Air Outlets and Inlets*, steel with baked white enamel finish except as noted, for installation on a fixed surface or a lay-in T-bar ceiling as indicated on architectural drawings, rigidly constructed, vibration free, with inlet collar of sufficient length to connect inlet ductwork, sized as shown on drawings. Where frames are provided for installation in fixed surfaces, frames shall be approximately 1-1/8" wide. Sound performance rated per ADC and based on room absorption of 10dBre10⁻¹² Watts and one diffuser.
1. Approved Manufacturers: Price, Krueger, Titus, Anemostat, OAE
- B. Types as follows. See also the Grille and Diffuser Schedule on drawings.
1. Square Ceiling Diffusers: Louvered type, 4-way pattern, 1-piece smooth aerodynamic surfaces with no corner joints, three louvers for 12-inch sizes, four louvers for 24-inch sizes, removable louver assembly, round neck, to provide stable, horizontal air flow without dumping down to 75 FPM inlet velocity for ceiling applications, and down to 20% of maximum air flow for non-ceiling applications. Price SCD.
 2. Round Ceiling Diffusers: Louvered type, 360-degree distribution, four separate 1-piece smooth aerodynamic louvers, adjustable air flow pattern (horizontal vs. vertical), round neck. Price RCD.
 3. Ceiling Return, Exhaust and Transfer Grilles: 1/2" x 1/2" x 1/2" egg crate type, steel frame for surface mounting or T-bar ceiling per application, aluminum grid. Price Series 80.
 4. Ceiling Rectangular Directional Diffusers: Louvered type, directional pattern as indicated on drawings, with removable louver assembly. Price SMD.

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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.
11. Laminar Flow Diffuser: Extruded aluminum construction and plated steel to inhibit corrosion. The perforated face plate, damper deflector, interior baffles and diffuser back pan plenum assembly shall be of 0.040 aluminum. The perforated face plate shall open easily with 90° quick-release fasteners and safety cable for easy cleaning and damper adjustment. B11 Sterile White-Thermal Setting finish. Krueger Model LFD or equivalent.

2.8 FANS

A. General

1. Construction
 - a. Factory fabricated fan, motor, drive and accessories, listed per UL, with air flow rated per AMCA 211 and sound rated per AMCA 301.
 - b. Fan wheel: Statically & dynamically balanced, with shaft sized so first critical speed is minimum 25% above maximum operating speed.

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- 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 12-inch galvanized steel, fiberglass insulated, with wood nailer, damper tray and flange. Provide cant and step if needed for proper seal with roof.
2. See Section 23 0548 for Vibration Isolation requirements.
- B. Centrifugal Roof Exhaust Fans
- 1. Leakproof construction.
 - 2. Housing: Spun aluminum construction, reinforced wind band welded to one-piece curb cap with mounting holes on the side and integral spun venturi, spun aluminum motor compartment with readily removable cover and breather tube. All other structural components shall be galvanized steel.
 - 3. Fan wheel: Backward inclined, centrifugal, non-overloading.
 - 4. Motor and Drive: Motor out of the air stream, cooled with ambient air. Motor, drive and fan wheel resiliently mounted on neoprene isolators.
 - 5. Electrical: Disconnect NEMA-1 if protected from the weather, or NEMA-3R if exposed to the weather, wired to motor, with all wiring and components per NEC and either UL Listed or UL recognized.
 - 6. Accessories: Stamped aluminum nameplate, hinge kit to allow tilting fan up to inspect wheel, retaining chains, conduit chase and roof curb.
 - 7. Approved Manufacturers: Greenheck Type, G, GB, CUE or CUBE as indicated. Cook, ACME, OAE.
- C. Laboratory Exhaust Fan
- 1. General: Factory fabricated, weatherproof for rooftop installation, with inlet plenum, fan assembly, bypass damper and discharge assembly, listed per UL 705.
 - a. Heavy gauge welded steel, powder costed, chemical and UV resistant, designed for wind speeds up to 125 MPH without guy wires,
 - b. Intake Plenum: With bypass dampers (low leakage airfoil type, corrosion resistant, similar to Greenheck), intake hood with bird screen, access panel, and roof curb.
 - c. All driveline components (motor, belt, drive, bearings, etc) located outside the contaminated air stream, and replaceable without exposure to the contaminated air stream. Belts & drives sized for 200% of motor HP, bearings sized for 200,000 hr L-10 life, shaft seal, AMCA Class B or C spark resistant construction,

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2. Mixed Flow Fan Style: Mixed flow fan with fan, motor and drive resiliently mounted on neoprene-in-shear isolators.
3. Centrifugal Fan Style: Backward inclined fan, housing with access door, fan and motor mounted on rigid steel frame, spring isolators with minimum 1-inch static deflection, and fabric inlet flexible connector.
4. Accessories: Color as selected by architect from among manufacturer's standard colors, windband acoustic attenuator, double wall plenum, isolation damper, roof curb, and factory wired electrical disconnect.
5. Approved Manufacturers: Greenheck Model MD or CD, Strobic Air, OAE.

2.9 COILS

- A. Galvanized steel casing, copper tubes and aluminum fins except as noted, with tubes mechanically expanded into fins, circuited to allow completely draining and venting coil, drain and vent connections, with performance rated per ARI. Do not exceed scheduled air or water pressure drops by more than 5 percent.

2.10 AIR HANDLING AND AIR CONDITIONING UNITS

A. General

1. Acoustical performance shall be established per ARI 260 rating procedures. Measurements will be taken in an ANSI 12.32 qualified room using a calibrated reference source per ARI 250. Sound data supplied shall meet or be less than requirements established later in this Specification. (Data presented in dBA, sones, Bels is not acceptable.)

B. Packaged AC Units, 2 – 12.5 Tons

1. General: Factory fabricated with ductwork connections as indicated on the drawings, suitable for rooftop installation, UL listed, ARI rated, factory piped and wired requiring only a single field power connection, factory run-tested, with casing, cooling section, gas heating section, fan section, accessories and controls.
2. Casing: Heavy gauge galvanized steel, weatherproof with exterior surfaces phosphatized and finished with baked enamel, hinged or removable panels for access to all components, water and air-tight seals for access panels, minimum 1/2-inch insulation, and hoods for intake and relief air. Provide a location for locating a fused disconnect on exterior of unit.
3. Cooling Section: Suitable for operation down to 55° F ambient, hermetic compressors, evaporator and condenser coils with copper tubes mechanically expanded into aluminum fins, all necessary refrigerant accessories, all necessary safety and operating controls, and double-pitched condensate pan. Provide fan guard for condenser fans.
4. Heating Section: Gas-fired, SS burner, corrosion resistant heat exchanger, direct spark ignition, forced draft or induced draft fan, all necessary safety and operating controls, complying with California requirements for low NOx emissions.

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5. Fan Section: Forward curved centrifugal, direct drive, with thermally protected motor, resiliently mounted.
6. Economizer: May be field installed, automatic motorized intake damper for 0 – 100% outside air intake, dry bulb type, with relief damper.
7. Accessories: 2-inch MERV 7 filters, 12-inch insulated roof curb with wood nailer and with cant and/or step if required to coordinate with roof.
8. Controls: Factory wired 24V microprocessor controls with controls transformer and thermostat for wall mounting.
9. Approved Manufacturers: Trane, Carrier, York, OAE.

C. Packaged AC Units 15 – 130 tons

1. General: Factory assembled, piped, wired, charged and run tested; packaged unit with casing, fan/motor/drive, refrigeration system, heating section, controls, and options and accessories as indicated; UL listed, cooling performance rated per ARI 360 and sound performance rated per UL 1995 Standards and ARI 210/240 or 360. Comply with the Equipment General Requirements specified in Section 23 0500.
2. Casing: Steel construction, configuration as shown on drawings, corrosion resistant finish to withstand a 1000-hour salt spray test per ASTM B117, weather-tight, roof pitched to shed water.
3. Fan, Motor and Drive(s): Centrifugal, 200,000 Hr L-50 bearings, V-belt drive.
4. Refrigeration System:
 - a. Compressor: Hermetic scroll type resistant to damage from slugging, with complete oil system including pump, sight glass, provisions for filling and testing oil, and crankcase heater.
 - b. Condenser: Coil with sub-cooling circuit. Fans: vertical direct drive propeller type, statically balanced, bearings with weather-tight slingers, motors with inherent thermal overload protection, resiliently mounted with fan guard.
 - c. Cooling Coil: With thermal expansion valve and distributor.
 - d. Refrigerant Piping System: Provide complete refrigerant piping system with piping, charging valve, compressor suction and discharge valves, and all necessary accessories.
5. Heating Section:
 - a. Gas Heat: Minimum 18-gauge heat exchanger factory pressure tested, heat exchanger cleanout door, fire tested prior to shipment.
 - b. Electric Heat: Heavy duty nickel chromium elements with maximum 40 watts per square inch, air flow switch, silent contractors and overcurrent protection.
 - c. Hot water heating coil.
6. Controls: Factory wired and tested with all necessary safety controls and all controls for fully automatic operation per the sequence of operations on the drawings. AC unit must be capable of fully automatic operation in a local mode in the event that communication with the FMS is lost. See controls drawings for the intended sequence of control and for the points associated with the FMS.

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- a. Include the necessary functionality to allow all user interface (for both initial setup and ongoing operation) to be through the FMS, and to accomplish the following through a BACNET or other approved open protocol interface:

<u>Function</u>	<u>What's by the AC Unit</u>	<u>What's by the FMS</u>
Supply Temperature	Unit Control (Note 1)	Reset supply temp setpoint
Space Temp Control	Unit Control (Note 3)	Monitor & Reset Setpoint
Fan Speed Control	Unit Control (Note 3)	Monitor duct SP, and reset SP control setpoint
Economizer	Unit Control	Monitor
Return/Relief Damper Control	Control	None
OA Damper Control (Note 2)	Unit Control	Setpoint adjustment
Units 25 Tons & Larger	All Measurement & Control	
Measure OA Supply		
15 – 20 T Units	NA	Only if shown on Controls Drawings
25 – 130 T Units:	Measure & transmit to FMS	Read
Scheduling	Unit operation	User interface, unit start/stop
Morning Warmup/Cooldown	Unit Control	Signal to initiate and terminate
Unoccupied Control	Unit Control	Signal to initiate and terminate
Duct Static Press Safeties	Unit Control	Measure & Monitor
System Alarms	Unit Control	Monitor & Reset Alarms

Note 1 It is acceptable to control the AC Unit heating and cooling systems based on return air temperature, provided the controls result in stable and reliable supply temperatures.

Note 2 OA supply reset (based on room CO₂ levels) may be implemented either initially or at some point in future. Include all functionality so the AC Unit can reset the minimum OA supply setpoint based on CO₂ levels measured and transmitted through the FMS.

Note 3 For single zone applications only.

- b. Include the necessary functionality to exchange all points with the FMS as indicated on the controls drawings and sequence of operations.
- c. Provide remote-mounted human interface panel to allow diagnosing and programming unit in the event that FMS connection has failed, and without having to go to unit.
- d. Ventilation Over-ride Control: To increase to 100% OA, initiated through the FMS and the Human Interface Panel.
- e. Work with the FMS contractor to integrate the AC unit controls with the FMS controls.
- f. Work with the FMS contractor for installation of all field-mounted controls supplied with the AC Unit.

D. Options & Accessories:

1. Casing: minimum 1-inch interior insulation minimum 14-inch roof curb, special sound curb, SS drain pan.

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2. Electrical and Control: Unfused disconnect, convenience receptacle, remote human interface panel
3. Refrigeration: R-134a, R-410a, automatic hot gas bypass, low ambient controls and all components to allow operating refrigerant system down to 0°F
4. Gas Heat: Minimum 80% efficient, 4:1 modulating control, SS heat exchanger
5. Filters: As specified elsewhere in this spec section, 2-inch MERV 8 Filters shall be located within the unit, not within the curb.
6. Fan(s): Fan and motor mounted on common steel base with seismically restrained spring isolators sized for minimum 2-inch static deflection. Provide supply and relief or return/relief relief fan with VFD with three contactor bypass. Provide extended lube lines.
7. Air Economizer: Automatic air-side economizer with OA damper and controls to fully modulate OA from 0 – 100%.
 - a. Controls: Dry bulb type
 - b. Relief Air: Variable speed relief fan with modulating return and relief air dampers.
 - c. OA and motorized relief damper: Leakage not to exceed 2.5% at 1-inch wg per AMCA Std. 575. OA and relief dampers: Air flow measuring type accurate to within 5% from 25% - 100% of scheduled air flows.
8. Approved Manufacturers: Trane Intellipak, York/Johnson Controls Series 20 through 100, McQuay, Carrier, OAE

E. Rooftop Semi-Custom CHW/HW Type

1. Factory assembled, horizontal type, weatherproof for outdoor installation, configured as indicated on drawings.
2. Casing: 2-inch double wall construction, minimum G-90 galvanized steel except as noted, with construction not less than the following: 16 ga exterior, 18 ga interior, 16 ga. floor. Provide 2-inch, 3-lb density fiberglass insulation completely separated from air stream, thermal break, perforated interior panels for sections upstream of cooling coil, solid interior panel for cooling coil, and perforated downstream of cooling coil. Panels shall be individually sealed. Maximum 0.5% deflection on perimeter and at section splits, with structural members under all concentrated loads. Design for minimum 6-inch negative SP upstream of fan, and 6-inch positive pressure downstream of fan. Safe off to prevent bypass around all unit components
3. Units shall be tested to a maximum leakage rate of 1% at 4-inch positive pressure
4. Provide access door and switched light in each accessible section. Provide access doors or removable panels to allow removal of all components, including dampers, filters, coils, fans, motors and drives. Access doors shall be double wall construction, min. 16-ga exterior and 22-ga interior, double sealed, hinged, with minimum 2 Ventlok 310 latches. Access doors shall open against air pressure. Provide window in door to mixing section, fan sections. Lights shall be marine type, factory installed and wired with switches, suitable for a single electric service connection at 115/1 phase, with minimum 2 switches
5. Provide vestibule adequately sized for installation and servicing all piping connections. Vestibule shall have floor at same level as unit. Provide continuous roof curb around entire periphery of unit and vestibule

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6. Fans: Plenum type, airfoil blades, statically and dynamically balanced, with inlet cone and removable expanded metal screen with doors for access to bearings, accessible 200,000 hour L-10 pillow block bearings with extended lubrication lines, premium efficiency inverter duty ODP motor per Section 23 0500, all components mounted on a rigid welded steel frame with spring isolators of minimum 2-inch static deflection. The fans are to be balanced to within a tolerance of 3 mil/second in all three axes. Provide V-belt drive sized for 150% of motor hp, with fixed sheaves, one replacement set of sheaves to be installed after balancing, and one spare set of belts
 - a. Note: Pressure drop through clean filters shall be included within AHU, not in external pressure drop
 - b. Sound data shall be certified per ARI standard 260 and reported as sound level for the air-handler (not just the fan)
 7. Coils: Certified per ARI. Heating Coil: Water type, drainable, 1/2" or 5/8" OD copper tubes, return bends, aluminum fins, galvanized steel casing, vent and drain connections, with capacities as scheduled. Water and air pressure drops shall not exceed those shown by 10 percent. Coil connections are same end. Provide holes through casing for piping connections. Cooling Coil: Refrigerant type with distributor, but the intent is to replace the cooling coil with CHW at some point in future, so include adequate space to allow for such future changeout. Provide SS drain pan for cooling coil, double pitched to eliminate standing water, sized to collect carryover, with threaded connection for field piping. Provide intermediate drain pans at each individual coil, with piped drain down to main drain pan
 8. Filters: MERV 7 per Section 23 3000.
 9. Dampers: Provide dampers as indicated on drawings. Configure dampers to maximize the mixing of RA and OA. Provide jackshaft linkages for dampers more than 4 ft long.
 10. OA damper: Low leakage, parallel blade type with integral airflow monitor, Ruskin IAQ. Return air damper: Parallel blade type, Ruskin CD-50. Relief air damper: Low leakage, opposed blade type with integral airflow monitor, Ruskin IAQ
 11. Approved manufacturers: York, Temtrol, Trane, Air Enterprises Akron, Ohio, Industrial Sheet Metal Rockingham, NC, Haakon, or Marcrafft Div of Johnson - Marcrafft St. Louis, Mo. Scott Springfield, Pace, or Energy Labs
- F. Rooftop Direct-Fired/Evap Cooled Makeup Air Unit
1. General: Factory fabricated, packaged rooftop, direct-fired with evap cooling, ETL Listed to ASNI Z83.4-1999, factory wired and tested (gas train, electrical components and air flow controls),
 2. Unit Construction: Heavy gauge G90 galvanized steel casing with corrosion resistant fasteners, weatherproof with standing seam where roof panels are joined, all metal-to-metal surfaces sealed where exposed to the weather, 1-inch fiberglass insulation, discharge configuration as indicated on drawings, access doors or removable panels for ready access to all components, and lifting lugs.
 3. Heating Section: Direct fired with cast aluminum burner, for use with natural gas at 900 – 1000 Btu/SCF HHV, SS mixing plates, Maxitrol or equivalent controls with 25:1 turndown, IRI or FM gas train, and all necessary safety and operating controls.

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4. Cooling Section: Evaporative type, SS module construction, 12-inch media with 90% cooling effectiveness, with float-type makeup, 120V pump with discharge piping and corrosion-resistant distribution header, drain & overflow connections.
5. Fan Section: AMCA rated for both performance and sound, centrifugal type statically and dynamically balanced, permanently lubricated bearings with 100,000 Hr L-10 life at maximum cataloged speed, belt driven with drive sized for 150% of motor HP, pulleys with machined surfaces, adjustable sheaves for 15 Hp and less, motor per Section 23 0500, fan discharge flexible connection, and with fan and motor mounted on common base.
6. Electrical and Controls: Factory wired for service from a single-point power connection, with all necessary power and control components mounted in accessible and weather-protected enclosures, all wiring per the NEC, control transformer with secondary fusing, contacts for remote start/stop and monitoring of fan status, and discharge temperature sensor with all components necessary for discharge temperature control. All components UL listed, recognized, or classified where applicable.
7. Approved Manufacturers: Greenheck Model DGX, Spec Air, Trane, Reznor, or approved equal

PART 3 EXECUTION

3.1 DUCTWORK AND PLENUMS

A. Ductwork

1. Construct ductwork with wall thicknesses and reinforcing per the SMACNA HVAC Duct Construction Standards, Second Edition, 1995, and UMC 2006 Chapter 6,
2. Pressure Classes: Construct ductwork to the following pressure classes:

<u>Duct Element Description</u>	<u>Relative Pressure</u>	<u>Pressure Class</u>
From Outside Air Louver to Filter:	N	1"
From Air Handling Unit to Terminal Unit:	P	4"
From Single Zone AHU to Diffuser	P	2"
From Terminal Unit to Diffuser:	P	1"
From Return Grille to Fan:	N	1"
From Return Fan to Relief Louver:	P	1"
From Exhaust Register to Exhaust Fan:	N	2"

3. Minimum thickness for sheet metal ductwork: 26 gauge.
4. Sealing: Seal ductwork and plenums as follows:

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-----Seal Class-----

----Supply Ducts----

Location	≤ 2 in. wg		≥ 2 in wg		Exhaust Return	
Outdoors	A	A	C	A		
Unconditioned Spaces			B	A	C	B
Conditioned Spaces including RA Plenums	C				B	B C

Seal ClassDescription _____.

- 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.

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14. Factory Made Air Ducts: Install in accordance with the terms of their listing and the manufacturer's recommendations.
 15. Acoustic Insulation: See Section 23 0700, HVAC Insulation. Fabricate ductwork so the dimensions indicated on the drawings are the clear dimensions for air flow inside the acoustic insulation.
 16. Coordination with Building Construction
 - a. General: The drawings show the general intended configuration of the ductwork. Provide additional offsets where necessary to coordinate with the building construction or with the work of other disciplines. Transition ductwork as required at no change in contract price. Where this is necessary, submit for review and maintain the indicated flow areas.
 - b. Ductwork is frequently routed through bar joists and between bar joists. Coordinate duct locations with joist submittals prior to fabrication.
- B. Special Applications
1. Moisture Laden Ductwork: Stainless steel with all joints liquid-tight by continuous external welding. Welds shall be free from pits, runs, spatter and other imperfections. Pitch horizontal ductwork downward to intake opening. Where traps occur that collect water, provide a 1/2-inch half coupling welded to the bottom of the duct and pipe to spill over nearest drain. Include a properly sized trap in the drain piping.
 2. Fume Hood Ductwork: Stainless steel with seams and joints continuously welded on the exterior. Spiral lock seam is not acceptable.
 3. Shower Room Exhaust Ductwork: Aluminum
 4. Ducts Handling Corrosive Vapors: Either stainless steel or galvanized steel with internal polyvinyl coating constructed and sealed as noted.
 5. Underslab Ductwork: Galvanized steel, polyvinyl coated on the exterior, constructed and sealed for 2-inch SP, insulated per Section 23 0700, and concrete encased. Concrete thickness shall be as indicated on the drawings, but not less than 2-inch thick.
 - a. Take care to prevent damaging ductwork when concrete is poured. Work with and provide guidance to the contractors responsible for pouring concrete and responsible for installing the building moisture protection system.
 - b. Anchor ductwork not more than 4-ft on centers to prevent floating. Use minimum 12-gauge wire or 16-gauge straps. Protect openings in ductwork with wood or metal blocking.
 - c. Pour concrete in maximum 12-inch lifts with each layer being allowed to set before pouring the next. Do not use power vibrators shall not be used in placement of concrete on or around ducts.
 6. Fiberglass Ductwork (Ductboard)
 - a. Provide fiberglass ductboard only where specifically indicated on the drawings and in this specification.
 - b. Install per UMC-06 Standard 6-05 – Standard for Installation of Factory-Made Air Ducts and SMACNA Standard 1884-2003 – Fibrous Glass Duct Construction Standard.

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- c. The drawings indicate required clear inside dimensions for air flow.
 - d. Where a duct constructed of ductboard penetrates a wall or floor which requires a fire damper, smoke damper, or fire/smoke damper, install the FD, SMD or FSD in the wall per its listing, make sheet metal connections to the damper if required, and then transition back to ductboard.
7. 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-gauge aluminum to protect the insulation. Repair any damage to the insulation jacket. Slope sheet metal enclosure to shed water.
- C. Hangers and Supports
1. Securely support ducts per SMACNA and UMC Table 6-7. Provide support at each concentrated load and at each change in direction. Provide supports on each side of rectangular ducts and equipment. Where vertical ducts pass through floors or roofs, support with angles or other steel members attached to minimum two opposite sides of duct. Size supports to rigidly support the ductwork. Provide lateral support.
 2. Hangers for terminal units: Minimum four 1" x 1/8" galvanized steel straps or two angle trapeze supports.
 3. Horizontal Round Ducts: 30 inches and larger in diameter: Provide 2" x 2" x 1/8" black steel rolled angle ring on 6-ft centers, and support from angle.
- D. Plenums
1. Single Wall Plenums: Shop fabricated minimum 16 gauge galvanized sheet steel. Horizontal and vertical panels are to be fabricated of 2' x 10' sheets. Unless otherwise dimensioned on the Drawings, access door frames are not to exceed 16-3/4 inch width. Where door width exceeds 16-3/4 inches, vertical panels shall be fabricated around 2" x 2" x 1/4" angle. If the plenum height or width exceeds 9 feet, provide a 2-1/2" x 1/8" continuous galvanized steel strip between each horizontal and vertical seam. Provide high velocity cement at each joint during panel assembly. Panels are to be bolted as shown on the details or tack welded at the Contractor's option; however, enough panels must be bolted to allow removal of equipment from the plenums. Cover interior surfaces with 2-inch thick, acoustical lining.
 - a. Plenum Access Doors: Minimum two fastening devices that can be operated on either side of the door; these devices to be readily operated and moving parts to have bronze pins. All parts of the door shall be constructed of galvanized iron and shall be airtight. Latches: "Ventlock" No. 310 OAE.
 2. Double Wall Plenums: Factory fabricated, Semco or equivalent. Submit shop drawings for review including overall configuration, construction details, access doors, erection drawings and structural calculations stamped by a registered structural engineer,.
 - a. Factory fabricated, minimum 18 gauge galvanized steel outside, perforated galvanized steel inside, with 2-inch sound insulation between. Plenums downstream of final filters shall have solid inner panel.
 - b. Heat transfer coefficient shall not exceed 0.0575 BTUH/SF-F at 75 deg F mean temperature. Pressure Ratings: 12 in. wg positive and 10 in. wg negative.
 - c. Noise attenuation shall be as follows in decibels, re 10⁻¹² watts.

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	OCTAVE BAND							
	1	2	3	4	5	5	7	8
Attenuation, db:	26	30	36	41	34	36	44	37
Noise Absorption Coeff:	0.22	0.39	1.20	1.36	1.03	0.84	0.74	0.68

3.2 DUCTWORK ACCESSORIES

- A. Dampers: Install dampers with shafts horizontal. Locate dampers so that actuators are readily accessible. Verify that dampers operate smoothly.
 - 1. Manual Dampers (Balancing Dampers): Damper Types D1 through D23 are all suitable for use as manual balancing dampers. Provide locking quadrants.
 - 2. Automatic Applications: The following damper types may be used for automatic applications: D4, D5, D6, D7, D21, D22 and D23. Provide damper actuators per Section 23 0900.

- B. Flexible Connectors: Provide flexible connectors at locations indicated on the drawings and at the inlet and outlet of each fan directly connected to duct system. Select flexible connectors appropriate for the application. Provide steel spring vibration isolators spanning across flexible connections of isolated fan housings to prevent blow-apart due to horizontal displacement of fan housings.

- C. Access Doors: Provide as required for access to all components located within ductwork. Locate to facilitate access to such components. Size as appropriate. In addition to locations specifically called out on the drawings or elsewhere in these specs, provide access doors at the following: FDs, SMDs, FSDs, instrumentation mounted within ductwork, fan bearings.

- D. Turning Vanes: Provide turning vanes in square elbows of all supply ducts. Single wall turning vanes may be used in ducts up to 1500 FPM and 24-inch vane length. Provide double wall turning vanes in ducts exceeding either of these criteria.

- E. Roof Curbs and Equipment Support Rails: Coordinate the location of roof curbs and rails with the roof structure, ductwork distribution, and other work. Install after roof deck is installed but before roof is insulated. Mount curbs and rails securely to deck per manufacturer's recommendations. Provide counterflashing as required.

- F. Louvers: Coordinate louver size and construction with structural and architectural openings to assure proper fit. Securely fasten louver to internal structural members to withstand a force of 25 lb/sf plus a safety factor of 3.0.

- G. Instrumentation: Install duct thermometers and filter gauges so they are easily readable from the operator level.

3.3 FLUES AND VENTS FOR FUEL-FIRED EQUIPMENT

- A. General: Install per the drawings and these specifications, manufacturer's instructions, the terms of the vent's UL Listing, the UMC and NFPA-211.

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1. Use the same type vent for the entire system from the equipment connection to the termination outside. Provide all fittings, transitions, adapters, supports, storm collars, etc.
 2. Install per the venting requirements of the appliance manufacturer. Comply with clearances per UL Listing. Minimize offsets and resistance to flow. System shall develop a positive flow adequate to remove products of combustion to outside. Do not run any portion of the vent system through any supply or return air duct or plenum. Do not connect the vent from any Category I or II (non-positive pressure) appliance with any Category III or IV (positive pressure) appliance. Do not install any manually operated damper at any point in vent system.
 3. Properly support the system and make provisions for thermal expansion. Install so as to prevent leakage of flue gases into the building. Provide drain connections where condensate is likely to accumulate, and pipe to spill over floor drain.
 4. Provide ventilated thimbles where vents pass through walls, floors and roof. Paint all galvanized or aluminized steel parts exposed to the weather with one coat of corrosion and heat-resistant primer, and one coat of heat resistant paint.
 5. Terminate low heat appliances as indicated on the drawings, but not less than:
 - a. 3 ft above the highest point where the vent passes the roof.
 - b. 2 ft above any portion of a building within a horizontal distance of 10 ft.
 - c. 3 ft above any forced air inlet located within 10 ft.
- B. Type B: If a draft damper is supplied with the appliance for installation in the flue, install it per manufacturer's instructions. If appliance is listed for use with a draft hood but is not supplied with one, provide a properly sized barometric draft regulator immediately in the vent outlet, and install per manufacturer's recommendations. Pitch vent up minimum 1/4-inch per foot. Join sections per manufacturer's recommendations using sheet metal screws or proprietary closure system of a UL Listed venting system. Provide vent cap,
- C. Type III and IV: Install per the drawings and these specifications, per manufacturer's instructions, per the terms of the vent's UL listing, and per NFPA-211.

3.4 DAMPERS FOR FIRE AND SMOKE CONTROL

- A. Select FDs, SMDs and FSDs as appropriate to the application. Dampers may be rectangular or round, and single-section or multi-section as required, but shall not be less than the duct sizes indicated on the drawings nor larger than the maximum sizes per the UL listing for a given style of damper. Provide transitions and sleeves as required.
1. FSDs may be used where SMDs are indicated provided they meet the required ratings of the indicated SMDs and provided the FSDs are installed in accordance with their listing.
- B. Install dampers in accordance with their listing. Terminate acoustic lining at dampers as necessary to ensure proper damper operation. Install actuators and access doors on the side of the duct unless space conditions preclude this. Provide adequate clearance for proper operation, and minimum 36-inch clearance for servicing actuator.

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1. When space conditions preclude installing actuators on the side, such components may be installed on the top or bottom of the duct provided good access to these components is maintained.
 2. When size requires the use of multiple dampers, provide framing to ensure the dampers remain in place.
 3. Provide a duct access door at each FD, SMD and FSD for inspection and maintenance. Provide minimum 1/2-inch high label, "SMOKE DAMPER," "FIRE DAMPER," or "FIRE/SMOKE DAMPER."
- C. Test all SMDs and FSDs after the system is installed to ensure proper operation based on both smoke and fire signals. Advise Owner minimum 2 weeks in advance and invite him to observe these tests. Submit a written report with a table which identifies each such damper (along with plans which indicate each such damper); gives its size, type and model number; the date on which it was tested; the test results; and places for the initials of the person performing test for the contractor and the person witnessing test for owner. Should any dampers fail to operate properly, service them and demonstrate proper operation. Reset all dampers when the testing is complete.

3.5 FILTERS AND FILTER GAUGES

- A. Provide one set of MERV-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.

3.6 TERMINAL UNITS

- A. Install terminal units so that controls and piping components are readily accessible for normal service and maintenance. Provide minimum 3 ft clear in front of control panels.

3.7 GRILLES REGISTERS AND DIFFUSERS

- A. Install grilles, registers & diffusers (GRDs) square with building construction. Mount sidewall GRDs minimum, 3-inches above floor level. If GRDs have provisions to adjust the direction of air flow, submit a written recommendation regarding the best direction for air flows, obtain written approval from the Owner's Representative, and adjust GRDs accordingly.
- B. Verify frame types with architectural RCPs prior to ordering GRDs.

3.8 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,

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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:

$$L_{\max} = C_L P^{0.65}, \text{ where}$$

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 are 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

SECTION 23 8113 VARIABLE REFRIGERANT FLOW (VRF) PIPING SYSTEM

PART 1 - GENERAL

1.1 REQUIREMENTS

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

1.2 SUMMARY

- A. This Section includes refrigerant piping used for Variable Refrigerant Flow HVAC applications.

1.3 RELATED SECTIONS

- A. Section 230500, Common Work Requirements for HVAC.
- B. Section 230504, Pipe and Pipe Fittings.
- C. Section 230700, HVAC Insulation.
- D. Section 238126, VRV Heat Pump With Heat Recovery
- E. Division 26, Electrical.

1.4 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.
- B. Installing Contractor to be certified by manufacturer prior to bid time.

1.5 PERFORMANCE REQUIREMENTS

- A. Line Test Pressure for Refrigerant R-410A:
 - 1. Liquid, Suction, & Discharge Gas Lines for VRV Applications: 550 psig for 24 hours.
- B. Triple Evacuation Test: Factory Authorized System commissioning to be included with bid.

1.6 SUBMITTALS

- A. Shop Drawings: Show layout of refrigerant piping on drawings, including Pipe Sizing Layout, valve arrangements and locations if thru-port shut off valves are to be used, connection details. Show interface and spatial relationships between piping and equipment.
 - 1. Shop Drawing Scale: 1/4 inch equals 1 foot.
 - 2. Refrigerant piping indicated on Drawings is schematic only. Piping Layout and Sizing to conform to VRF Equipment Manufacturer's requirements and piping limitations to ensure proper operation and compliance with warranties of connected equipment.
- B. Welding certificates.
- C. VRF Installation Training certificates
- D. VRF Commissioning agent name and certificate
- E. Field quality-control test reports.

1.7 QUALITY ASSURANCE

- A. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
- B. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems." Any substitution is responsible for showing compliance with ASHRAE Standard 15 at time of submittal
- C. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.8 PRODUCT STORAGE AND HANDLING

- A. Store piping in a clean and protected area with end caps in place to ensure that piping interior and exterior are clean when installed.

1.9 COORDINATION

- A. Coordinate size and location of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

- A. All tubing shall be rigid (no coiled tubing).
- B. Copper Tube: Refrigeration Copper Type L or ACR.

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- C. Wrought-Copper Fittings: ASME B16.22.
- D. Wrought-Copper Unions: ASME B16.22.
- E. See Evaluations for discussions of solder and brazing materials.
- F. Brazing Filler Metals: 15% Silver Brazing Alloy

2.2 VALVES AND SPECIALTIES

- A. Valves:
 - 1. Install Complete Thru-Port manual isolation valves with downstream pressure port on inlet and outlet of every piece of equipment.
- B. Specialties: NOT ALLOWED
 - 1. Filter Driers, Strainers, Flexible Connectors, Sight Glasses, Moisture Indicators, Oil Traps, Check Valves, Non Thru-Port Service Valves, Solenoid Valves, Pressure Relief Valves, Thermostatic Expansion Valves, Mufflers, Liquid Accumulators, or other Specialties are **NOT PERMITTED TO BE USED** with any VRF System per Manufacturer's requirements.

2.3 REFRIGERANTS

- 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. Atofina Chemicals, Inc.
 - 2. DuPont Company; Fluorochemicals Div.
 - 3. Honeywell, Inc.; Genetron Refrigerants.
 - 4. INEOS Fluor Americas LLC.
- B. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. The system must be installed by a manufacturer factory trained contractor/dealer. The bidders shall be required to submit training certification proof with bid documents. The mechanical contractor's installation price shall be based on the systems installation requirements. The mechanical contractor bids with complete knowledge of the HVAC system requirements.

3.2 PIPING APPLICATIONS FOR REFRIGERANT R-410A

- A. Liquid, Suction, & Discharge Gas Lines for Variable Refrigerant Flow Air-Conditioning Applications: Copper, Type L or ACR, annealed-temper tubing and wrought-copper fittings with brazed joints.

3.3 VALVE AND SPECIALTY APPLICATIONS

- A. Complete Thru-Port Manual Shut Off Valves with Downstream Pressure Taps may be used if scheduled or shown on drawings.
 - 1. Filter Driers, Strainers, Flexible Connectors, Sight Glasses, Moisture Indicators, Oil Traps, Check Valves, Non Thru-Port Service Valves, Solenoid Valves, Pressure Relief Valves, Thermostatic Expansion Valves, Mufflers, Liquid Accumulators, or other Specialties are **NOT PERMITTED TO BE USED** with any VRF System per Manufacturer's requirements.

3.4 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.
- B. Install refrigerant piping according to ASHRAE 15.
- C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- F. Install piping adjacent to machines to allow service and maintenance.
- G. Install piping free of sags, bends, & traps.
- H. Install fittings for changes in direction.
- I. Select system components with pressure rating equal to or greater than system operating pressure.
- J. Install Refrigerant Piping In Accordance With VRF Manufacturer's Installation Requirements.
- K. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

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- L. Arrange piping to allow inspection and service of refrigeration equipment. Install valves if required in accessible locations to allow for service and inspection. Install access doors or panels as specified in Division 08 Section "Access Doors and Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.
- M. Install refrigerant piping in protective conduit where installed belowground and all underground piping must adhere to VRF manufacturer's installation requirements.
- N. Install Expansion Loops per VRF manufacturer's installation requirements as required.
- O. When brazing refrigerant piping a minimum 3psi Dry Nitrogen purge is required to prevent oxidation formation on the interior walls of the brazed joint.
- P. Install VRF manufacturer's RefNET Fittings or Headers where lines branch off to Branch Selector Boxes or Air Handler locations. Standard Tee or Y fittings are not permitted.
- Q. Identify refrigerant piping and valves according to Division 23 Section "Identification for HVAC Piping and Equipment."
- R. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 23 Section "Sleeves and Sleeve Seals for HVAC Piping."
- S. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 23 Section "Sleeves and Sleeve Seals for HVAC Piping."
- T. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 23 Section "Escutcheons for HVAC Piping."

3.5 PIPE JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Fill pipe and fittings with an inert gas (nitrogen), during brazing or welding, to prevent scale formation.
- D. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."
 - 1. Use 15% Silver Brazing Alloy for joining copper fittings with copper pipe.

3.6 HANGERS AND SUPPORTS

- A. Hanger, support, and anchor products are specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."
- B. Install the following pipe attachments:

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1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet long.
 2. Horizontal Runs of VRF Refrigerant Piping to be free-floating to allow for expansion and contraction of copper pipe. Eaton BPS Series Saddle supports shall be used such that the pipe insulation is not compressed. Piping shall not be installed directly on Unistrut. If clamps are required use clamps that allow for pipe to move inside insulation. Zip ties shall not be used.
 3. Hydrosorb or Cushion Clamps are not permitted for horizontal runs but may be used for vertical runs of VRF refrigerant piping.
- C. Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:
1. NPS 1/2: Maximum span, 60 inches; minimum rod size, 1/4 inch.
 2. NPS 5/8: Maximum span, 60 inches; minimum rod size, 1/4 inch.
 3. NPS 1: Maximum span, 72 inches; minimum rod size, 1/4 inch.
 4. NPS 1-1/4: Maximum span, 96 inches; minimum rod size, 3/8 inch.
 5. NPS 1-1/2: Maximum span, 96 inches; minimum rod size, 3/8 inch.
- D. Support multi-floor vertical runs at least at each floor.

3.7 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
- B. Manufacturer's agent to provide periodic on site inspections during construction to verify compliance with installation requirements.
- C. Tests and Inspections:
1. Comply with ASME B31.5, Chapter VI.
 2. Test Liquid, Suction, & Discharge Gas refrigerant piping lines to 550psi dry nitrogen for 24hrs per VRF manufacturer's requirements. Test piping of each system separately at not less than the pressures indicated in Part 1 "Performance Requirements" Article.
 - a. Fill system with nitrogen to the required test pressure.
 - b. System shall maintain test pressure at the manifold gage throughout duration of test.
 - c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
 - d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

3.8 SYSTEM EVACUATION

- A. Evacuate system using the following procedures:
1. Use vacuum pump capable of 29+ inches of vacuum

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2. Confirm VRF Condensing Unit main shut off valves are closed completely.
3. Vacuum Pump to have check valve to prevent mineral oil to be drawn into system.
4. Vacuum Pump to have fresh oil prior to evacuation.
5. Evacuate entire refrigerant system with a vacuum pump to hold at 4000 microns.
6. Break vacuum with dry nitrogen to 2-3psi pressure and hold for 15 minutes.
7. Evacuate entire refrigerant system with a vacuum pump to hold at 1500 microns. Hold for 20 minutes.
8. Break vacuum with dry nitrogen to 2-3psi pressure and hold for 15 minutes.
9. Evacuate entire refrigerant system with a vacuum pump to hold at 500 microns. Hold for 60 minutes minimum.
10. System is ready to add additional refrigerant charge.
11. Additional Refrigerant Charge To Be Calculated By VRF Equipment Manufacturer's Representative.

3.9 SYSTEM CHARGING

- A. Charge system using the following procedures:
1. Use only R-410A Refrigerant.
 2. Liquid only to be added to system.
 3. Calculate amount of refrigerant required to be added prior to starting process and verify that compliance with ASHRAE Std 15 is being maintained.
 4. Follow VRF Manufacturer's procedures to charge system.
 5. Once charged, VRF Condensing Unit main shut off valves can be opened and system can be commissioned.

END OF SECTION

SECTION 23 8126 VRF HEAT PUMP WITH HEAT RECOVERY

PART 1 GENERAL

1.1 REQUIREMENTS

- A. Comply with all requirements in the General Conditions, Supplemental General Conditions, and Division 1 – General Requirements.

1.2 PRE-INSTALLATION MEETING

- A. Convene one week prior to commencing work related to products of this section; require attendance of all affected installers, the manufacturer’s representative, the general contractor, the owner’s representative and the engineer of record.

1.3 SYSTEM DESCRIPTION

- A. The variable capacity, heat recovery air conditioning system basis of design Daikin Emerion Variable Refrigerant Flow System as specified.
- B. Operation of the system shall permit either individual cooling or heating of each fan coil simultaneously. Each fan coil shall be able to provide set temperature independently.

1.4 QUALITY ASSURANCE

- A. The units shall be listed by Electrical Laboratories (ETL) and bear the cETL label.
- B. All wiring shall be in accordance with the National Electric Code (NEC).
- C. The system shall be factory tested for safety and function.

1.5 DELIVERY, STORAGE AND HANDLING

- A. Unit shall be stored and handled according to the manufacturer’s recommendations.

1.6 WARRANTY

- A. The units shall have a manufacturer’s warranty for a period of one (1) year from date of substantial completion. The units shall have a warranty for a period of one (1) year from date of substantial completion. The compressors shall have a warranty of six (6) years from date of substantial completion. All warranty service work shall be performed by a factory trained service professional.

1.7 INSTALLATION REQUIREMENTS

- A. The system must be installed by a factory trained contractor/dealer. The mechanical contractor's installation price shall be based on the systems installation requirements.

PART 2 EQUIPMENT

2.1 GENERAL SYSTEM OPERATING RANGE

- A. The operating range in cooling will be -4°F DB - 122°F DB.
- B. The operating range in heating will be -13°F WB – 60°F WB
- C. Simultaneous cooling/heating operating range will be 22°F WB ~ 60°F WB.

2.2 OUTDOOR UNIT

- A. Product Design
 - 1. The heating and cooling system shall be an air cooled system allowing user to configure in the field a heat pump or a heat recovery system consisting of one to three outdoor unit modules, conjoined to make a 6 to 42 ton single refrigerant circuit.
 - a. Heat recovery systems, employing three pipes, shall be connected to Heat recovery (heat recovery) unit(s) and indoor unit(s). Multi-port heat recovery units shall allow simultaneous heating and cooling of individual zone(s) at various capacities as required to satisfy their zone requirements.
 - b. Heat pump systems shall require two pipes, simultaneous heating and cooling shall not be supported. The heat recovery system shall consist of three pipes, liquid, suction and hot gas pipes. Heat recovery systems operating at 0°F that cannot deliver single phase superheated refrigerant vapor at a minimum of 162°F while operating in the heating mode shall not be acceptable.
 - 2. All three-phase VRF heat pump and heat recovery outdoor units shall be from the same product development generation. Mixing of outdoor units from different development generations is not acceptable.
- B. Operating Conditions
 - 1. Outdoor Unit shall be capable of continuous compressor operation between the following operating ambient air conditions, operation outside of these conditions are possible and may involve non-continuous operations.
 - 2. Operating Ambient Air Conditions:
 - a. Cooling: -4°F DB to 122°F D
 - b. Heating: -22°F WB to 60°F WB
 - c. Cooling Based (ODU reversing valve in cooling position) Synchronous: 14°F DB to 81°F DB (Heat Recovery Operation Only)

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- d. Heating Based (ODU reversing valve in heating position) Synchronous: 14°F WB to 61°F WB (Heat Recovery Operation Only)

C. Electrical

- 1. All air source heat pump and heat recovery frame(s) shall be designed and electrically protected to maintain stable continuous compressor operation when provided with 460/60/3 power with the following specifications:
 - a. 460/60/3
 - 1) Voltage fluctuation of $\pm 10\%$
 - 2) Voltage imbalance of up to two percent;
 - 3) Power surge of up to 5kA RMS Symmetrical.

D. General Features

- 1. The air-conditioning system shall use R410A refrigerant.
- 2. Each system shall consist of one, two or three air source outdoor unit modules conjoined together in the field to result in the capacity specified elsewhere in these documents.
- 3. Dual and triple frame configurations shall be field piped together using manufacturer's designed and supplied Y-branch kits and field provided interconnecting pipe to form a common refrigerant circuit.
- 4. System shall have following frame configurations vs. capacity.
 - a. 6 to 20 ton units shall be a single frame only.
 - b. 22 to 34 ton units shall be dual frame only.
 - c. 36 to 42 ton heat recovery units shall be triple frame only
- 5. System shall employ self-diagnostics function to identify any malfunctions and provide type and location of malfunctions via fault alarms.
- 6. Field Provided Refrigerant Piping:
 - a. The refrigerant circuit shall be constructed using field provided ACR copper, de-hydrated, refrigerant rated copper pipe, piped together with manufacturer supplied Heat recovery unit(s) and Y- branches, as may be required, connected to multiple (ducted, non-ducted or mixed combination) indoor units to effectively and efficiently control the heat pump operation or simultaneous heating and cooling operation of the heat recovery VRF system. Other pipe materials, if used, shall perform, at a minimum, as well as that specified above, shall not have any adverse reactions, for example galvanic corrosion, to any other components or materials also in use in the system and shall be installed per manufacturer's instructions.
 - b. The unit shall be shipped from the factory fully assembled including internal refrigerant piping, inverter driven compressor(s), controls, temperature sensor, humidity sensor, contacts, relay(s), fans, power and communications wiring as necessary to perform both Heat Pump and Heat recovery operations.
 - c. Each outdoor unit refrigeration circuit shall include, but not limited to, the following components:
 - 1) Refrigerant strainer(s)

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- 2) Check valve(s)
 - 3) Inverter driven, medium pressure vapor injection, high pressure shell compressors
 - 4) Liquid refrigerant cooled inverter PCB
 - 5) Oil separator(s)
 - 6) Accumulator /controlled volume receiver(s)
 - 7) 4-way reversing valve(s)
 - 8) Vapor injection valve(s)
 - 9) Variable path heat exchanger control valve(s)
 - 10) Oil balancing control
 - 11) Oil Level sensor(s)
 - 12) Electronic expansion valve(s)
 - 13) Sub-cooler (s)
 - 14) Vapor Injection Valve(s)
 - 15) High and low side Schrader valve service ports with caps
 - 16) Service valves
7. Field Insulation:
- a. All refrigerant pipe, y-branches, elbows and valves shall be individually insulated with no air gaps. Insulation R-value (thickness) shall not be less than the minimum called for by the local building code, local energy code or as a minimum per manufacture installation requirements. In no case shall the insulation be allowed to be compressed at any point in the system.
 - 1) All joints shall be glued and sealed per insulation manufactures instructions to make an air tight assembly.
8. Microprocessor:
- a. Factory installed microprocessor controls in the outdoor unit(s), heat recovery unit(s), and indoor unit(s) shall perform functions to optimize the operation of the VRF system and communicate in a daisy chain configuration between outdoor unit and heat recovery unit(s) and indoor unit(s) via RS485 network. Controls shall also be available to control other building systems as required from the VRF control system. DIO/AIO capabilities shall be available as well as a central controller to perform operation changes, schedules and other duties as required by this specification. Addition of separate building control system shall not be required. Other control devices and sequences shall be as specified in other sections of this project specification.
9. Inverter PCB Cooling:
- a. Cooling of the inverter PCB shall be conducted by way of high pressure, sub-cooled liquid refrigerant via heat exchanger attached to the inverter PCB. The full capacity flow of refrigerant shall pass though the heat exchangers to maximize the cooling effect of the PCBs and to aid in the evaporation process and capacity of the outdoor coil during the heating mode. The recovered heat of the PCBs must be

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used to enhance the overall heating process, other uses or dissipation of heat to ambient shall not be permitted.

10. Compressor Control:
 - a. Fuzzy control logic shall establish and maintain target evaporating temperature (T_e) to be constant on cooling mode and condensing temperature (T_c) constant on heating mode by Fuzzy control logic to ensure the stable system performance.
11. Initial Test Run (ITR) (Heating or Cooling) / Fault Detection Diagnosis (FDD) Code:
 - a. This control mode shall monitor and display positive or negative results of system initial startup and commissioning. Heating or Cooling ITR mode will be automatically selected. It shall monitor and provide performance metrics for the following, but not be limited to, refrigerant quantity charge, auto-charge, stable operations, connection ratios, indoor unit status, error status, and number of indoor units connected. This control mode shall not replace the system error monitoring control system.
12. BMS Integration:
 - a. The VRF system shall be able to integrate with Building Management Systems via BACnet™ IP gateway. This gateway converts between BACnet™ IP or Modbus TCP protocol, and RS-485 allowing third party control and monitoring of the A/C system, or LonWorks™ gateways. See controls specification for points list.
13. Indoor Unit Connectivity:
 - a. The system shall be designed to accept connection up to 64 indoor units of various configuration and capacity, depending on the capacity of the system.
14. Power and Communication Interruption:
 - a. The system shall be capable of performing continuous operation when an individual or several indoor units are being serviced; communication wire cut or power to indoor unit is disconnected. Systems that alarm and/or shut down because of a lack of power to any number of indoor units shall not be acceptable.
15. Connection Ratios:
 - a. The maximum allowable system combination ratio for all VRF systems shall be 130% and the minimum combination ratio shall be 50%.
16. Comfort Cooling Mode:
 - a. Comfort cooling shall be initiated via a field setting at the outdoor unit during commissioning or anytime thereafter. Comfort cooling shall allow user to select all or some of the zones on a system to adjust automatically their evaporator temperatures, independent of other zones, based on the impending total loads of that zone determined by using the zone controller temperature sensor.
17. The outdoor unit refrigerant circuit shall employ for safety a threaded fusible plug.
18. Refrigerant Flow Control
 - a. An active refrigerant control and multi section accumulator-receiver that dynamically changes the volume of refrigerant circulating in the system based on operating mode and operating conditions to ensure maximum system performance and efficiency.

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- b. Subcooler: The VRF outdoor unit shall include a factory provided and mounted sub-cooler assembly consisting of a shell and tube-type sub-cooling heat exchanger and EEV providing refrigerant sub-cooling modulation control by fuzzy logic of EEV and by mode of operation to provide capacity and efficiency as required. Brazen plate heat exchangers shall not be allowed for this function.
 - c. Smart Load Control: The air source unit shall be provided with Smart Load Control (SLC) enhanced energy saving algorithm that reduces compressor lift during off peak operation.
 - 1) The SLC algorithm shall be monitoring in real time, the rate of change of the outdoor ambient air temperature, either the outdoor ambient air relative humidity or the indoor air relative humidity [field selectable], and the rate of change of the building load.
 - 2) The SLC algorithm shall foresee pending changes in the building load, outdoor temperature and humidity (or indoor humidity) and proactively reset head and/or suction pressure targets in anticipation of the reduction/increase in building load.
 - 3) The SLC algorithm shall provide no fewer than 3 field selection options to maximize the control of the VRF system operation during morning warm-up or cool-down following night-setback reset. The selection shall be set by the commissioning agent (or at any other time thereafter). Selectable algorithm choices include:
 - a) Maximize energy savings
 - b) Balance the rate of temperature change with energy consumed.
 - c) Quickly cool/heat the building.
19. Refrigerant Volume Management
- a. Active Refrigerant Charge
 - 1) The VRF system shall be able to operate at any and all published conditions year round in cooling or heating mode without the need of adding or removing refrigerant from the system.
 - 2) The air source unit shall be provided with an isolated vessel to store spare refrigerant and actively pass refrigerant to (or from) the accumulator in real time as necessary to maintain stable refrigeration cycle operation.
 - 3) The air source unit microprocessor shall be provided with an algorithm that monitors the VRF system head pressure, suction pressure, subcooling, superheat, compressor speed, high and low side temperatures and the load on the system to adjust the volume of refrigerant actively circulating.
 - b. Manual Seasonal Refrigerant Charge Adjustments
 - 1) Alternates: Systems that CANNOT passively and automatically modify the active refrigerant charge using the method(s) stated to maintain stable cycle operation shall clearly state so in bold capital letters in the proposal. VRF systems that cannot perform active refrigerant control may submit a proposal as an Alternate and must include as part of the equipment price the cost of to provide bi-annual refrigerant charging services for 15 years. Service shall be performed by the factory authorized agent only. Service

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shall include refrigerant, parts, labor, and fees necessary to analyze the current state of the system and perform the refrigerant charge adjustment. Service must occur one month before the winter season and one month before the summer season.

- 2) If the VRF system requires a charge adjustment more frequently to maintain stable operation, the VRF manufacturer shall provide additional services at no additional charge.
 - 3) The 15 year period shall begin on the date the equipment is commissioned or the date the building occupancy permit was issued for the area(s) served by the system – whichever date is later.
 - 4) This service shall be underwritten, warranted, and administered by the VRF equipment manufacturer – not the local distributor or applied representative.
 - 5) The selected service provider shall be mutually agreeable between the building owner (or owners agent) and must be licensed, insured, and trained to work on the VRF system. No third party service (subcontracted service) providers will be acceptable.
 - 6) If the service provider is not an employee of the VRF manufacturer, the service provider shall be reimbursed for services rendered directly from the manufacturer. Labor rate for services shall be paid at the prevailing wage rate in place at the time of service.
20. VRF Systems with Onboard Alternate Operating Mode Selection Capability
- a. All VRF systems which provide field selectable Alternate Operating Modes, for example, High Heat or High Ambient Cooling, published data tables must be available to the public for all modes offered.
 - b. Acceptable Alternate Operating Modes must ship with all models of the VRF product offering and must be factory embedded. Custom factory or field modifications to factory provided algorithms created to meet scheduled requirements are not acceptable.
 - c. Provide a copy of instructions required to set the Alternate Operation Mode with the initial submittal.
 - d. For systems that provide field selectable Alternate Operating Modes, ALL technical data provided in the submittal data sheets showing product rated condition performance data, must also provide separate data sheets that show product performance data at each of the field selectable Alternate Operating Modes available. Capacity, power input, and acoustic performance data for each mode offered shall be reported separately. Mixing of ODU, IDU, or VRF system performance capability operating in one mode with for example the power consumption, sound power rating, or electrical requirements of the same system operating in another mode is not acceptable.
- E. Field Supplied Refrigerant Piping Design Parameters
1. The outdoor unit shall be capable of operating at an elevation difference of up to 360 feet above or below the lowest or highest indoor unit respectively without the requirement of field installed subcooler or other forms of performance enhancing booster devices.

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2. The outdoor unit shall be capable of operating with up to 3280 equivalent length feet of interconnecting liquid line refrigerant pipe in the network.
3. The outdoor unit shall be capable of operating with up to 656 actual feet or 738 equivalent length feet of liquid line refrigerant pipe spanning between outdoor unit and farthest indoor unit.
4. The piping system shall be designed with pipe expansion and contraction possibilities in mind. Required expansion devices shall be field designed, supplied and installed based on proper evaluation of the proposed piping design. In addition to these requirements, the piping system installation must conform to the VRF equipment manufacturer's published guidelines.
5. The installation of pipe hangers, supports, insulation, and in general the methods chosen to attach the pipe system to the structure must allow for expansion and contraction of the piping system and shall not interfere with that movement.
6. The elevation differences for heat recovery systems shall be:
 - d. Heat recovery unit to connected indoor unit shall be 49 feet
 - e. Heat recovery unit to heat recovery unit shall be 98 feet
 - f. Indoor unit to indoor unit connected to same heat recovery unit shall be 49 feet
 - g. Indoor unit to indoor unit connected to separate parallel piped heat recovery units shall be 131 feet.
7. The acceptable elevation difference between two series connected heat recovery units shall be 16 feet.

F. Defrost Operations

1. The outdoor unit(s) shall be provided with a minimum of 4 independent field adjustable defrost cycle algorithms to maximize the effectiveness of the defrost cycle to the local weather conditions. Intelligent Defrost shall melt accumulated frost, snow and ice from the outdoor unit heat exchanger. The defrost cycle length and sequence shall be based on outdoor ambient temperatures, outdoor unit heat exchanger temperature, and various differential pressure variables. Intelligent Heating Mode, when outdoor unit humidistat is engaged, shall extend the normal heating sequences by adjusting the outdoor unit coil target temperature to be above the ambient dew point temperature delaying the need for defrost operations, so long as heating demand is being met.
2. Smart Heating: This feature shall be capable of eliminating several defrost actions per day based on outdoor air temperature and humidity conditions. Smart heating shall extend the heating operation cycle by delaying the frost formation on the outdoor coil by adjusting the surface temperature to keep it above the current outdoor ambient dew point. The algorithm shall delay while maintaining indoor space temperature.
3. Defrost Mode Selection: The outdoor unit shall be provided with a minimum of three field selectable defrost operation modes: Normal, Fast, or Forced.
 - a. Normal Defrost: Operation intended for use in areas of the country that experience adverse winter weather with periods of heavy winter precipitation and extremely low temperatures. This strategy shall maximize the systems heating performance and maintain operational efficiency. When the ambient temperature is either: a) above 32°F or b) below 32°F with the humidity level below 60% RH,
Intelligent

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Defrost shall continue heating regardless of ice build-up on the coil until the quality of the heated air (i.e. discharge air temperature) decreases. At temperatures below 4°F, a defrost cycle shall occur every two hours to optimize system heating efficiency.

- b. Fast Defrost: Operation intended for use in areas of the country with mild winter temperatures and light to moderate humidity levels. The strategy minimizes defrost cycle frequency allowing frozen precipitation to build longer in between cycles. Minimum time between defrost cycles shall be 20 minutes. Intelligent Defrost shall choose between split coil/frame and full system methods based on current weather conditions to minimize energy consumption and maximize heating cycle time.
 - c. Forced Defrost: Operation shall be available for the service provider to test defrost operations at any weather condition and to manually clear frozen water from the outdoor coil surfaces.
4. Defrost Method Selection: The outdoor unit shall be provided with two field selectable defrost operation methods: Split Coil/Frame and Full System. Split Coil/Frame option provides continuous heating of the occupied space during defrost operation.
- a. Split Coil/Frame method shall be available when Normal Defrost mode is selected. Split Coil method shall be available on all Heat Pump and Heat recovery single-frame VRF systems. Split Frame defrost shall be available on all Heat Pump and Heat recovery multi-frame outdoor units.
 - b. Split Coil method shall remove ice from the bottom half of the outdoor unit coil first for a maximum time of six minutes, then the top half for a maximum of six minutes. Next the bottom coil shall be heated again for an additional three minutes to remove any frozen water that may have dripped onto the lower coil during the top coil defrost operation.
 - c. When Split Coil/Frame method is selected, a Full System defrost shall occur every 1-9 (field selectable) defrost cycles to assure 100% of the frozen precipitation has been removed to maintain efficient performance.
 - d. Full System method shall be available as a field selectable option. All outdoor units located in areas of the country where large volumes of frozen precipitation are common, the commissioning agent shall be able to select the Full System only defrost method.
5. Indoor Unit Fan Operation During Defrost
- a. During partial defrost operation indoor units operating in cooling or dry mode shall continue normal operation.
 - b. During partial defrost operation, indoor units that are commissioned with fans set for continuous operation shall maintain normal fan speed unless the leaving air temperature drops, then the fan speed will be reduced to low speed for the remainder of the defrost cycle.
 - c. During full system defrost operation indoor unit fans will cycle off and remain off during the remainder of the defrost cycle.

G. Oil Management

1. The system shall utilize a high pressure oil return system to ensure a consistent film of oil on all moving compressor parts at all points of operation. Oil is returned to compressor

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through a separate high pressure oil injection pipe directly into the oil sump. Oil returned to the compressor via the suction port of the compressor shall not be allowed.

2. Each compressor shall be provided with a high efficiency independent centrifugal cyclone type oil separator, designed to extract oil from the oil/refrigerant gas stream leaving the compressor.
3. The system shall have an oil level sensor in the compressor to provide direct oil level sensing data to the main controller. The sensor shall provide data to main outdoor unit PCB to start oil return mode and balance oil levels between multiple compressors.
4. The system shall only initiate an oil return cycle if the sensed oil level is below oil level target values as determined by the microprocessor. The system shall display an error if the oil sensor signals low oil level for a period of 130 minutes or longer.
5. A default oil return algorithm shall automatically initiate the oil return mode if the system detects a failure of the oil sump sensor. A fault code shall be reported by the system.
6. Timed oil return operations or systems that do not directly monitor compressor oil level shall not be permitted.
7. Indoor Unit Fan Operation during Oil Return Cycle
 - a. During oil return cycle indoor units operating in cooling or dry mode shall continue normal operation.
 - b. During oil return, indoor units that are commissioned with fans set for continuous operation shall maintain normal fan speed unless the leaving air temperature drops, then the fan speed will be reduced to low speed for the remainder of the oil return cycle.
 - c. During oil return cycle indoor unit fans will cycle off and remain off during oil return cycle while operating in all modes.

H. Fan and Motor Assembly

1. 6 ton frames shall be equipped with one direct drive variable speed propeller fan with Brushless Digitally Controlled (BLDC) motor with a vertical air discharge.
2. 8 to 20 ton frames shall be equipped with two direct drive variable speed propeller fan(s) with BLDC motor(s) with a vertical air discharge.
3. The fan(s) blades shall be made of Acrylonitrile Butadiene Styrene (ABS) material and incorporate biomimetic technology to enhance fan performance and reduce fan generated noise.
4. The fan(s) motor shall be equipped with permanently lubricated bearings.
5. The fan motor shall be variable speed with an operating speed range of 0-1150 RPM cooling mode and 0-1150 RPM heating mode.
6. The fan shall have a guard to help prevent contact with moving parts.
7. The cabinet shall have option to redirect the discharge air direction from vertical to horizontal with the addition of optional factory provided air guides.
8. The fan controller shall have a DIP switch setting to raise external static pressure of the fan up to 0.32 inch of W.C. to accommodate ducted installations.
9. The fan control shall have a function setting to remove excess snow automatically.

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10. The fan control shall have a function setting to remove access dust and light debris from the outdoor unit and coil.

I. Cabinet

1. Outdoor unit cabinet shall be made of 20 gauge galvanized steel with a weather and corrosion resistant enamel finish. Outdoor unit cabinet finish shall be tested in accordance with ASTM B-117 salt spray surface scratch test (SST) procedure for a minimum of 1000 hours.
2. Cabinet weights and foot prints shall vary between 430 lbs., 7.61 sq. ft. (1.27 sq. ft. per ton), for 6 ton cabinet to 666 lbs., 10.14 sq. ft. (.51 sq. ft. per ton), for 20 ton cabinet for single cabinet configurations. The front panels of the outdoor units shall be removable type for access to internal components.
3. A smaller service access panel, not larger than 7" x 7" and secured by a maximum of (2) screws, shall be provided to access the following:
 - a. Service tool connection
 - b. DIP switches
 - c. Auto addressing
 - d. Error codes
 - e. Main microprocessor
 - f. Inverter PCB
4. The cabinet shall have piping knockouts to allow refrigerant piping to be connected at the front, right side, or through the bottom of the unit.
5. The cabinet shall have a factory installed coil guard.

J. Outdoor Unit Coil

1. Outdoor unit coil shall be designed, built and provided by the VRF outdoor unit manufacturer.
2. The outdoor unit coil for each cabinet shall have lanced aluminum fins with a maximum fin spacing of no more than 17 Fins per Inch (FPI). All the outdoor unit coils shall be a 2 or 3 rows consisting of staggered tubes for efficient air flow across the heat exchanger
3. Outdoor unit coil shall be comprised of aluminum fins mechanically bonded to copper tubing with inner surfaces having a riffling treatment to expand the total surface of the tube interior
4. The aluminum fin heat transfer surfaces shall have factory applied corrosion resistant Black Fin coating. The copper tubes shall have inner riffling to expand the total surface of the tube interior.
 - a. ISO 21207 Salt Spray Test Method B – 1500 hours
 - b. ASTM B-117 Acid Salt Test – 900 hours
 - c. The Black Fin coating shall be certified by Underwriters Laboratories and per ISO 21207. The above conditions shall establish the minimum allowable performance which all alternates must comply.

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5. Variable Path Heat Exchanger: System shall have a variable flow and path outdoor heat exchanger function to vary the refrigerant flow and volume and path. Control of the variable path circuits shall be based on system operating mode and operating conditions as targeted to manage the efficiency and minimize or maximize the circulating volume of the operating fluids of the system. This feature allows MV 5 to maintain system head pressure that delivers “gas-furnace leaving air temperature” from the indoor unit at moderate and low ambient outdoor air temperatures.
6. The outdoor unit coil, all indoor units and pipe network shall be field tested to a minimum pressure of 550 psig.

K. Compressor(s)

1. Compressor shall be designed and assembled by the VRF manufacturer specifically for use in the air source VRF product line. Third party manufactured, branded, or designed to the VRF system’s OEM specifications by a third party manufacturer shall not be acceptable.
2. Compressor shall be a hermetic, high-side shell (HSS), commercial grade, compliant scroll direct-drive design.
 - a. Compressor Design: The compressor design shall be of the high pressure shell scroll type where the internal pressure below the suction valves of the compressor shall be at the same high pressure and high temperature. The motor shall be cooled by high pressure gas at temperatures above saturation conditions and minimize the mixing of refrigerant liquid with oil in the sump. The system shall employ a high pressure oil return method returning recovered oil from the oil separator directly into the oil sump of the compressor; oil shall not be allowed to return via the suction line. Bearing surfaces are continually coated with oil. The compressor shall employ an Aero-bearing constructed with high lubricity materials increasing operation time in case of low sump oil level. Compressor shall have a nominal operating range from 12Hz to 150 Hz.
3. The fixed and oscillating compressor scroll components shall be made of high grade (GC25) or denser steel material. All scrolls shall be heat treated and tempered.
4. The oscillating scroll shall be finely machined and polished. PVE refrigerant oil shall be used as the sole liquid used to maintain a seal between the high and low sides of the compression chamber. Compressors that requires the use of any type of mechanical or wearable sealant material between the moving surfaces of the compression chamber is NOT ACCEPTABLE.
5. Vapor Injection: System shall have a medium pressure gas vapor injection function employed in the heating and cooling modes to increase system capacity when the outdoor ambient temperatures are low and lower compressor lift when temperatures are high. The compressor vapor injection flow amount shall be controlled by the vapor injection sub-cooling algorithm reset by discharge gas temperatures of the compressor.
6. Bearing surfaces shall be coated with Teflon® equal. Bearings shall be lubricated using a constant flow of PVE refrigerant oil to the bearing surfaces The film of oil separating the crankshaft journals and bearing surfaces shall be consistent at all times the crankshaft is in motion and shall be maintained irrelevant of crankshaft rotational speed.
7. An internal, integrated, mechanically driven gear pump shall draw oil from the compressor sump reservoir, pressurize the oil and inject the oil directly to the crankshaft

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journals maintaining a consistent film of oil between all moving parts. Auxiliary, indirect, or electronically driven pumps are not acceptable.

8. The viscosity property of the PVE oil in the compressor sump shall be maintained irrelevant of compressor operation and the surrounding ambient temperature.
 - a. The compressor shall be equipped with an external thermally protected electric crankcase heater that is automatically activated only when the ambient temperature is below freezing and the compressor is not running to maintain the temperature of the oil in the sump above the refrigerant boiling point.
 - b. During stable operation, irrelevant of ambient air temperature outside the water source unit, the temperature of refrigerant vapor in contact with the surface of the oil in the compressor sump shall be maintained above 140°F to prevent foaming and to eliminate refrigerant from mixing with the oil degrading the viscosity of the oil in the sump.
9. The compressor motor shall be designed to operate at high temperatures.
 - a. The motor winding insulation shall be designed to operate continuously at a minimum temperature of 180°F without deterioration.
 - b. The motor cooling system shall be designed to maintain acceptable operational temperature at all times and in all conditions using high pressure, hot refrigerant vapor as motor coolant.
10. Inverter Compressor Controller(s)
 - a. Each compressor shall be equipped with a dedicated inverter compressor drive. The control of multiple compressors using a single drive is not acceptable.
 - b. The inverter drive shall vary the speed of the compressor crankshaft between zero (0) Hz and 140 Hz.
 - c. The inverter driver controller shall be matched with the physical properties of the compressor. The drive shall be manufactured by the VRF air source unit manufacturer. The inverter drive and matching compressor shall have been thoroughly tested as a matched pair. The inverter drive shall be programmed to avoid operating the compressor at any speed that results in harmonic vibration, nuisance noise, or mechanical damage to either the driver or the compressor with power provided that is within the tolerance specification.
 - d. The compressor inverter drive assembly and software must be designed, manufactured, and supplied by the VRF product manufacturer. Third party branded inverter driver hardware and/or driver software or inverter driver hardware and/or software provided by a third party manufacturer to meet OEM specifications of the VRF water source manufacturer will not be acceptable.
 - e. All inverter drive hardware or software manufactured in, is a product of, or sourced from China, or using a broker or third party provider as an intermediary that obtains the product from CHINA shall not be acceptable.
11. Compressor(s)
 - a. Each 6, 8, 10 ton frames shall be equipped with a single hermetically sealed, inverter driven, High Side Shell (HSS) scroll compressor.

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- b. 12, 14, 16, 18 and 20 ton frames shall be equipped with dual hermetically sealed, inverter driven, High Side Shell (HSS) scroll compressors.
- c. Each inverter driven, HSS scroll compressor shall be capable of operating from 12 Hz up to 150 Hz in any and all modes (cooling, heating or simultaneous modes).
- d. The compressor shall be designed for a separate port for oil to be directly returned to the compressor oil sump.
- e. The compressor bearing(s) shall have Teflon™ coating and shall be an aero type design using High lubricity materials.
- f. The compressor(s) shall be protected with:
 - 1) High Pressure switch
 - 2) Over-current /under current protection
 - 3) Oil sump sensor
 - 4) Phase failure
 - 5) Phase reversal
 - 6) Compressor shall be capable of receiving injection of medium pressure gas at a point in the compression cycle where such injection shall allow a greater mass flow of refrigerant at lower outdoor ambient and achieving a higher heating capability. The VRF outdoor unit shall have published performance data for heating mode operation down to -13°F on both heat pump and heat recovery systems.
- g. Standard, non-inverter driven compressors shall not be permitted nor shall a compressor without vapor injection or direct sump oil return capabilities.

L. Operational Sound Levels

- 1. Each single frame outdoor unit shall be rated with an operational sound pressure level not to exceed as listed on below chart when tested in an anechoic chamber under ISO 3745 standard at the highest field selectable heating operating modes available. Such documentation shall be presented in all submittals, manufactures who elect to rate their equipment at other than tested in an anechoic chamber under ISO 3745 standard at the highest field selectable heating operating modes available and the highest field selectable conditions shall not be allowed.
- 2. A field setting shall be available to program the outdoor unit to reduce sound levels at night, when desired, to a selectable level while still able to meet building load requirement. This mode is available in both cooling and heating modes.

M. Sensors

- 1. Each outdoor unit module shall have:
 - a. Suction temperature sensor
 - b. Discharge temperature sensor
 - c. Oil level sensor
 - d. High Pressure sensor

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- e. Low Pressure sensor
- f. Outdoor temperature sensor
- g. Outdoor humidity sensor
- h. Outdoor unit heat exchanger temperature sensors

N. Warranty

1. Limited Warranty Period

- a. STANDARD ONE-YEAR PARTS WARRANTY FOR A QUALIFIED SYSTEM - The Part(s) of a qualified System, including the compressor, are warranted for a period (the “Standard Parts Warranty Period”) ending on the earlier to occur of one (1) year after the date of original installation, or eighteen (18) months from the date of manufacture.
- b. ADDITIONAL SIX (6) YEAR COMPRESSOR PART WARRANTY - The Compressor is warranted for an additional six (6) year period after the end of the applicable Standard Part Warranty Period (the “Compressor Warranty Period”).

2.3 BRANCH SELECTOR UNIT

A. General

- 1. Heat recovery unit shall be designed and manufactured by the same manufacturer of VRF indoor unit(s) and outdoor unit(s).
- 2. Heat recovery unit casing shall be constructed with galvanized steel.
- 3. Heat recovery unit shall require 208-230V/1-phase/60Hz power supply.
- 4. Heat recovery Unit shall be an intermediate refrigerant control device between the air source outdoor unit and the indoor units to control the systems cooling and heating operation.
- 5. Heat recovery unit shall be engineered to work with a three pipe VRF system comprising of:
 - a. High Pressure Vapor Pipe
 - b. Low Pressure Vapor Pipe
 - c. Liquid Pipe
- 6. Heat recovery units’ main 3 pipe connections shall be capable of series or parallel pipe configuration.
- 7. The quantity of heat recovery units that can be piped in series shall be limited to 16.
- 8. A single string of series piped heat recovery units shall be capable of serving any combination of styles of VRF indoor units with a combined nominal capacity of up to 240 MBh.
- 9. Heat recovery unit shall have 2, 3, 4, 6 or 8 ports, each port supporting one or more indoor units with a maximum connected capacity of 60 MBH.
- 10. Each port shall be capable of operating in cooling or heating independently regardless of the operating mode of any other port on the heat recovery unit or in the system.

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11. Each port shall be capable of connecting from 1 to 8 indoor units.
12. Connection to indoor units totaling greater than 60MBh nominal capacity shall be twinned to two adjacent ports of the heat recovery unit using a reverse Y-branch connector supplied by manufacture.
13. Heat recovery unit shall be internally piped, wired, assembled and run tested at the factory.
14. Heat recovery unit shall be designed for installation in a conditioned environment per specifications.
15. Heat recovery unit shall employ a liquid bypass valve.
16. Heat recovery unit shall have (2) electronic expansion refrigerant valves per port.
17. Heat recovery unit shall have a balancing valve to control the pressure between the high pressure and low pressure pipe during mode switching to minimize any change-over pressure related sounds.
18. Heat recovery unit shall employ an electronic expansion valve to ensure proper sub cooling of the refrigerant.
19. Heat recovery unit shall contain one double spiral sub-cooling heat exchanger per port.
20. Heat recovery unit shall not require a condensate drain or connection.
21. Heat recovery unit shall be internally factory insulated.
22. All field refrigerant lines between outdoor unit and heat recovery unit and from heat recovery unit to indoor unit shall be field ACR tubing, insulated per building or energy code and as instructed by the manufacture.
23. The heat recovery unit shall not exceed a net weight of 70 lbs.
24. Heat recovery units, for line length and pressure drop calculations, shall not exceed a maximum equivalent pipe length value of 8.2 feet.
25. The VRF manufacturer shall provide published documentation that specifically allows the installation of field provided isolation valves on all pipes connected to the Heat recovery unit to allow the servicing of heat recovery units, refrigerant circuit or the replacement of heat recovery unit without evacuating the balance of the piping system.

B. Controls

1. Heat recovery unit(s) shall have factory installed unit mounted control boards and integral microprocessor to communicate with other devices in the VRF system.
2. Heat recovery unit shall communicate with the indoor units via a 2-conductor stranded communications cable terminated using a daisy chain configuration.
3. The contractor is instructed to review the Electrical and ATC drawings and specifications for other items or tasks which this contractor is or may be responsible to provide materials and or labor under this contract. Failure to do so will not relieve this contractor of their responsibility to provide such materials and or labor and in no case shall this contractor be further compensated as a result.

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C. Seismic Installations

1. Provide OSHPD Special Seismic Certification Preapproval (OSP) documents for certified product list of VRF equipment to be installed in high seismic risk areas. Provide LG supplemental installation documents in conformance with CBC 2013, 2016 and 2019 California Building Code and IBC 2012, 2015 and 2018 International Building Code.

2.4 CASSETTE FAN COIL UNIT

A. General

1. Unit shall be designed to be installed for indoor application.
2. Unit shall be designed to mount recessed in the ceiling and has a surface mounted grille on the bottom of the unit.
3. The unit shall be available in both nominal 2' x 2' and 3' x 3' chassis.

B. Casing/Panel

1. Unit case shall be manufactured using galvanized steel plate.
2. The unit panel shall be provided with an off-white or black Acrylonitrile Butadiene Styrene (ABS) polymeric resin grille.
3. The grille shall have a tapered trim edge, and a hinged, spring clip (screw-less) return air filter-grille door.
4. Unit shall be provided with metal ears designed to support the unit weight on four corners.
5. Ears shall have pre-punched holes designed to accept field supplied all thread rod hangers.
6. Unit shall be supplied with snap off access panels to facilitate leveling of unit without removing the grille.

C. Cabinet Assembly

1. Unit shall have four supply air outlets and one return air inlet.
2. The supply air outlet shall be through four directional slot diffusers each equipped with independent oscillating motorized guide vanes designed to change the airflow direction.
3. The grille shall have a discharge range of motion of 40° in an up/down direction with capabilities of locking the vanes.
4. The unit shall have a guide vane algorithm designed to sequentially change the predominant discharge airflow direction in counterclockwise pattern.
5. Guide vanes shall provide airflow in all directions.
6. Unit shall be equipped with factory installed temperature thermistors for:
 - a. Return air
 - b. Refrigerant entering coil
 - c. Refrigerant leaving coil

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7. Unit shall have a factory assembled, piped and wired electronic expansion valve (EEV) for refrigerant control.
8. Unit shall have a built-in control panel to communicate with other indoor units and to the outdoor unit.
9. The unit shall have factory designated branch duct knockouts on the unit case.
10. The unit shall have provision of fresh air ventilation through a knock-out on the cabinet.
11. The branch duct knockouts shall have the ability to duct up to 1/2 the unit airflow capacity.
12. The branch duct cannot be ducted to another room.
13. Unit shall have the following functions as standard:
 - a. Self-diagnostic function
 - b. Auto addressing
 - c. Auto restart function
 - d. Auto changeover function (Heat Recovery system only)
 - e. Auto operation function
 - f. Child lock function
 - g. Forced operation
 - h. Dual thermistor control
 - i. Sleep mode
 - j. Dual set point control
 - k. Multiple aux heater applications
 - l. Filter life timer
 - m. External on/off input
 - n. Wi-Fi compatible
 - o. Auto fan operation
 - p. Leak detection logic

D. Fan Assembly

1. The unit shall have a single, direct-drive turbo fan made of high strength ABS HT-700 polymeric resin.
2. The fan impeller shall be statically and dynamically balanced.
3. The fan motor is Brushless Digitally commutated (BLDC) with permanently lubricated and sealed ball bearings.
4. The fan motor shall include thermal, overcurrent and low RPM protection.
5. The fan/motor assembly shall be mounted on vibration attenuating rubber grommets.
6. The fan speed shall be controlled using microprocessor based direct digitally controlled algorithm that provides a minimum of four pre-programmed fan speeds in the heating mode

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and fan only mode and five speeds in the cooling mode. The fan speed algorithm provides a field selectable fixed speed.

7. A field setting shall be provided to vary air throw pattern to compensate for high ceiling installations.
8. In cooling mode, the indoor fan shall have the following settings: Low, Med, High, Super high, Power Cool, and Auto.
9. In heating mode, the indoor fan shall have the following settings: Low, Med, High, Super high and Auto.
10. Unit shall have factory installed motorized louver to provide flow of air in up and down direction for uniform airflow.

E. Filter Assembly

1. The return air inlet shall have a factory supplied removable, washable filter.
2. The unit shall have the capability to accept a field provided MERV 1 to MERV 10 filter.
3. The filter access shall be from the bottom of the unit without the need for tools.
4. The nominal 3'x3' cabinet unit shall have provision for an optional auto-elevating grille kit designed to provide motorized ascent/descent of the return air grille/pre filter assembly.
 - a. The ascent/descent of the return air grille shall be up to a distance of 14-3/4 feet allowing access to remove and clean the filter.
 - b. The auto-elevating grille shall have a control algorithm to accept up, down and stop control commands from the controller.
 - c. The auto-elevating grille shall have a control to stop the descent automatically if a contact is made with any obstacle.

F. Coil Assembly

1. Unit shall have a factory built coil comprised of aluminum fins mechanically bonded on copper tubing.
2. The copper tubing shall have inner grooves to expand the refrigerant contact surface for high efficiency heat exchanger operation.
3. Unit shall have a minimum one or two row coil, 18-19 fins per inch.
4. Unit shall have a factory supplied condensate drain pan below the coil constructed of EPS (expandable polystyrene resin).
5. Unit shall include an installed and wired condensate drain lift pump capable of providing minimum 27.5 inch lift from bottom surface of the unit.
6. The drain pump shall have a safety switch to shut off the unit if condensate rises too high in the drain pan.
7. Unit shall have provision of 45° flare refrigerant pipe connections.
8. The coil shall be factory pressure tested at a minimum of 550 psig.

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9. All refrigerant piping from outdoor unit to indoor unit shall be field insulated. Each pipe should be insulated separately. Thickness and heat transfer characteristics shall be determined by the design engineer and shall meet all code requirements.

G. Microprocessor Control

1. The unit shall have a factory installed microprocessor controller capable of performing functions necessary to operate the system.
2. The unit shall be able to communicate with other indoor units and the outdoor unit using a field supplied minimum of 18 AWG, two core, stranded, twisted and shielded communication cable.
3. The unit controls shall operate the indoor unit using one of the five operating modes:
 - a. Auto changeover (Heat Recovery System only)
 - b. Heating
 - c. Cooling
 - d. Dry
 - e. Fan only
4. The unit shall be able to operate in either cooling or heating mode for testing and/or commissioning.
5. The unit shall be able to operate with the fan turned off during system cooling thermal off.
6. The unit shall have adjustable, multi-step cooling and heating mode thermal on/off temperature range settings.
7. The system shall include a product check function to access and display indoor unit type and capacity from a wired programmable thermostat controller.
8. Unit shall have a field settable method to choose auto fan speed change operation based on mode of operation, on/off fan operation based on mode of operation, or continuous minimum set fan speed operation.

H. Electrical

1. The unit electrical power shall be 208-230/1/60 (V/Ph/Hz).
2. The unit shall be capable of operating within voltage limits of +/- 10% of the rated voltage.

I. Controls

1. Unit shall use controls provided by the manufacturer to perform all functions necessary to operate the system effectively and efficiently and communicate with the outdoor unit over an RS-485 daisy chain.

J. Warranty

1. Please refer to the respective outdoor unit for applicable warranty.

2.5 DUCTED FAN COIL UNITS

A. General

1. Unit shall be manufactured by Daikin.
2. Unit shall be designed to be installed for indoor application.
3. Unit shall be designed to mount fully concealed above the finished ceiling.
4. Unit shall have opening to supply air from front horizontal and a dedicated rear horizontal return.
5. The supply air shall be flanged for field installed ductwork that shall not exceed the external static pressure limitation of the unit.

B. Casing/Panel

1. Unit case shall be manufactured using galvanized steel plate.
2. The cold surfaces of the unit shall be covered internally with a coated polystyrene insulating material.
3. The cold surfaces of the unit shall be covered externally with sheet insulation made of Ethylene Propylene Diene Monomer (M-Class) (EPDM)
4. The external insulation shall be plenum rated and conform to ASTM Standard D-1418.
5. Unit shall be provided with hanger brackets designed to support the unit weight on four corners.
6. Hanger brackets shall have pre-punched holes designed to accept field supplied, all thread rod hangers.

C. Cabinet Assembly

1. Unit shall have horizontal supply air discharge outlets and a return air inlet
2. Unit shall be equipped with factory installed temperature thermistors for:
 - a. Return air
 - b. Refrigerant entering coil
 - c. Refrigerant leaving coil
3. Unit shall have a factory assembled, piped and wired electronic expansion valve (EEV) for refrigerant control.
4. Unit shall have a built-in control panel to communicate with other indoor units and to the outdoor unit.
5. Unit shall have the following functions as standard:
 - a. Self-diagnostic function
 - b. Auto addressing
 - c. Auto restart function
 - d. Auto changeover function (Heat Recovery system only)
 - e. Auto operation function

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- f. Child lock function
- g. Forced operation
- h. Dual thermistor control
- i. Sleep mode
- j. External static pressure (ESP) control
- k. Dual set point control
- l. Multiple aux heater applications
- m. Filter life timer
- n. External on/off input
- o. Wi-Fi compatible
- p. Auto fan operation
- q. Leak detection logic

D. Fan Assembly

- 1. The unit shall have two direct drive Sirocco fans made of high strength ABS GP-2200 polymeric resin.
- 2. The fan impeller shall be statically and dynamically balanced.
- 3. The fans shall be mounted on a common shaft.
- 4. The fan motor is Brushless Digitally commutated (BLDC) with permanently lubricated and sealed ball bearings.
- 5. The fan motor shall include thermal, overcurrent and low RPM protection.
- 6. The fan/motor assembly shall be mounted on vibration attenuating rubber grommets.
- 7. The fan speed shall be controlled using microprocessor based direct digitally controlled algorithm that provides a minimum of three pre-programed fan speeds, each setting is also adjustable by field setting to compensate for a limited amount of additional resistance to airflow by adjusting the RPM of the fan motor.
- 8. In cooling mode, the indoor fan shall have the following settings; Low, Med, High, and Auto.
- 9. In heating mode, the indoor fan shall have the following settings: Low, Med, High, and Auto.
- 10. Each of the settings can be field adjusted from the factory setting (RPM/ESP).
- 11. Unit shall be designed for high speed air volume against an external static pressure of up to 0.98" water gauge, model dependent.

E. Filter Assembly

- 1. The return air inlet shall have a factory supplied MERV 13 filter rack.
- 2. The filter access shall be from the rear of the unit.

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F. Coil Assembly

1. Unit shall have a factory built coil comprised of aluminum fins mechanically bonded on copper tubing.
2. The copper tubing shall have inner grooves to expand the refrigerant contact surface for high efficiency heat exchanger operation.
3. Unit shall have a minimum two to three row coil, 19-21 fins per inch.
4. Unit shall have a factory supplied condensate drain pan below the coil constructed of HIPS (high impact polystyrene resin).
5. Unit shall include an installed and wired condensate drain lift pump capable of providing minimum 27.5 inch lift from bottom surface of the unit. The unit drain pan is supplied with a secondary drain port/plug allowing the pan to be gravity drained and serviced.
6. The drain pump shall have a safety switch to shut off the unit if condensate rises too high in the drain pan, model dependent.
7. Unit shall have provision of 45° flare refrigerant pipe connections.
8. The coil shall be factory pressure tested at a minimum of 550 psig.
9. All refrigerant piping from outdoor unit to indoor unit shall be field insulated. Each pipe should be insulated separately. Thickness and heat transfer characteristics shall be determined by the design engineer and shall meet all code requirements.

G. Microprocessor Control

1. The unit shall have a factory installed microprocessor controller capable of performing functions necessary to operate the system with or without the use of a wall mounted controller. The unit shall have a factory mounted return air thermistor for use as a space temperature control device. All operating parameters except scheduling shall be stored in non-volatile memory resident on the microprocessor. The microprocessor shall provide the following functions, self-diagnostics, auto re-start after a power failure and a test run mode.
2. The unit shall be able to communicate with other indoor units and the outdoor unit using a field supplied minimum of 18 AWG, two core, stranded, twisted, and shielded communication cable.
3. The unit controls shall operate the indoor unit using one of the five operating modes:
 - a. Auto changeover (Heat Recovery System only)
 - b. Heating
 - c. Cooling
 - d. Dry
 - e. Fan only
4. The unit shall be able to operate in either cooling or heating mode for testing and/or commissioning.
5. The unit shall be able to operate with the fan turned off during system cooling thermal off.

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6. The unit shall be able to operate with a continuous fan setting.
7. The unit shall have adjustable, multi-step cooling and heating mode thermal on/off temperature range settings.
8. The system shall include a product check function to access and display indoor unit type and capacity from a wired programmable thermostat controller.

H. Electrical

1. The unit electrical power shall be 208-230/1/60 (V/Ph/Hz).
2. The unit shall be capable of operating within voltage limits of +/- 10% of the rated voltage.

I. Controls

1. Unit shall use controls provided by the manufacturer to perform all functions necessary to operate the system effectively and efficiently and communicate with the outdoor unit over an RS-485 daisy chain.

J. Warranty

1. Please refer to the respective outdoor unit for applicable warranty.

2.6 2 TO 5 TON HEAT PUMP CONDENSING UNITS

A. Product Design

1. Variable Refrigerant Flow (VRF) HVAC outdoor unit shall be a variable capacity, direct expansion (DX), Heat Pump engineered system. The VRF system shall consist of a single frame outdoor unit, interconnecting piping, multiple indoor units (ducted, non-ducted or mixed combinations), onboard, self-contained, stand-alone communication and controls.
2. Outdoor units shall be manufactured as Heat Pump model capable of heating and/or cooling. Heat pump models shall be able to heat OR cool separate thermal zones.
3. Heat pump systems shall require two pipes, between the outdoor unit and indoor units. Simultaneous heating and cooling is not supported. One pipe shall support bidirectional flow single state liquid refrigerant. The other pipe shall support bidirectional flow of single state refrigerant gas. In heating mode the gas shall be super-heated high pressure. In cooling mode the gas shall be low pressure, low temperature.
4. Heat pump and Heat recovery outdoor units shall be designed to communicate directly with all VRF indoor units manufactured by the same supplier over a field supplied stranded, twisted and shielded pair wire. Systems requiring intermediary protocol translators, signal boosters, integration with a third party building management systems (BMS) or any other device required for communication possible shall not be accepted.
5. Indoor unit connectivity: The system shall be designed to accept connection up to 12 indoor units of various configurations and capacity. Number of indoor units allowed:
 - a. 2 ton HP 4 IDUs
 - b. 3 ton HP 6 IDUs
 - c. 4 ton HP 8 IDUs

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- d. 5 ton HP 12 IDUs
6. Combination Ratio (CR) is defined as sum of nominal cooling capacity of proposed indoor units/nominal cooling capacity of the outdoor unit. The maximum allowable system combination ratio shall be 130%. Systems designed with combination ratio above 130% are not acceptable. The total nominal capacity of all indoor units shall be no less than 50%.
- B. Operating Conditions
- 1. The VRF systems shall be capable of providing continuous compressor operation over the required ambient operating range. Submittal or technical performance data that indicates the required operating ambient range includes data points that do not guarantee continuous compressor operation, noted or footnoted as reference data, shall not be accepted. The required ambient operating range is defined as follows:
 - a. Cooling
 - 1) Heat Pump & Heat recovery System: 23°F DB to 122°F DB
 - b. Heating
 - 1) Heat Pump - 4°F WB to 61°F WB
 - c. Heat Recovery Synchronous (Simultaneous heating and cooling)
 - 1) Cooling based: 14°F DB to 81°F
 - 2) Heating-based: 14°F WB to 61°F WB
- C. Electrical
- 1. ALL air source heat pump and heat recovery frame(s) shall be designed and electrically protected to maintain stable continuous compressor operation when provided with 460/60/3 power and can withstand:
 - a. 460/60/3 power and can withstand a voltage fluctuation of $\pm 10\%$
 - b. Power surge of up to 5kA RMS Symmetrical.
- D. General Features
- 1. The unit shall be shipped from the factory fully assembled including internal refrigerant piping, inverter driven compressor, controls, contacts, relay(s), fan(s), power and communication wiring.
 - 2. The refrigerant shall be R410A. The factory shall supply the following charge of refrigerant R410a:
 - a. 2 ton HP 4.0 lbs.
 - b. 3 ton HP 6.6 lbs.
 - c. 4 ton HP 6.6 lbs.
 - d. 4.4 ton HP 6.6 lbs.
 - e. 5 ton HP 7.7 lbs
 - 3. All outdoor units, regardless of the Heat Pump or Heat Recovery models, shall be the same generation and provide with most up to date firmware version at the time of

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delivery. Manufacturers commissioning agents shall assure the owner in the commissioning report that the latest software version.

4. If the specifications include both heat pump and heat recovery outdoor models, the manufacturer shall provide the most recent generation equipment only. Old stock or obsolete models will not be accepted. Products purchased over the internet and not from the manufacturer's authorized local mechanical representative or authorized distributor will not be accepted.
5. The outdoor unit refrigeration circuit at a minimum shall include the following components:
 - a. Refrigerant strainer(s)
 - b. Check valve(s)
 - c. Inverter driven, high pressure shell compressor
 - d. Oil separator
 - e. Accumulator/receiver
 - f. 4-way reversing valve
 - g. Electronic expansion valve(s)
 - h. Double spiral tube sub-cooler and EEV
 - i. High/low Schrader valve service ports with caps
 - j. High/low service valves
 - k. Threaded fusible plug
 - l. High pressure switch
6. The VRF outdoor unit shall use the sub-cooler while operating in cooling mode to sub-cool liquid refrigerant coming from the condenser coil well below saturation temperature to ensure that refrigerant remains in 100% liquid state when it reaches the farthest indoor unit's EEV valve. The amount of sub-cooling shall be modified by the microprocessor controller and minimized at all times to maximize efficiency by not overcooling the liquid.
7. Third Party Controls platform Integration
 - a. The VRF system manufacturer's central controls platform shall be able to communicate with third party building management systems (BMS) via BACnet IP, Modbus TCP, or LonWorks™ protocol allowing third party BMS system control and/or monitoring of the LG air conditioning and heating system. See controls specification for more detailed description of integration and points to be controlled and monitored.

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- b. The VRF system manufacturer shall have available off-the shelf devices that allows on/off binary interfaces between third party ancillary devices such as fans, door locks, photo eyes, key card switches, motion sensors, exhaust fans, dampers, and a single (or group of) VRF indoor units. Indoor units shall have the ability to start/stop the third party device, receive a contact closure signal from the third party device, or have the third party device change the operating conditions of the VRF indoor unit. Operating conditions shall include one or more of the following indoor unit functions: fan speed, fan on/off, thermal on/off cooling or heating, or indoor unit start/stop.
8. Wi-Fi communication:
 - a. The outdoor unit shall be Wi-Fi-capable. Wi-Fi shall allow service or maintenance personal access to the operating system diagnostics and monitoring functions, via the manufacturer's provided maintenance and diagnostic software over a mobile device or personal computer. Communication between devices shall include: 1) Real-time system operation monitoring with the ability to capture all system operating data for a field determined period of time into a downloadable csv file format to a wireless connected device; 2) Collection of point in time (snapshot) information including all current outdoor unit operating conditions and each indoor unit, system EEV and solenoid valves, sensors, compressor speed, and refrigerant operating pressures. Systems that require computers with a hard wire only connection or other devices to collect, review or record operating conditions shall not be allowed.
 9. Microprocessor Control
 - a. Factory installed microprocessor control in the outdoor unit, heat recovery unit(s), and indoor unit(s) shall communicate using the same protocol. Translators of any kind are not allowed. Communication between VRF system components shall be via field supplied stranded, shielded and twisted wire pair in a RS 485 network configuration. Integrated control system shall perform functions to optimize the operation of the VRF system.
 - b. Power and communication interruption: The system shall be capable of performing continuous operation when an individual or several indoor units are being serviced; communication wire cut or power to indoor unit is disconnected. Systems that alarm and/or shut down because of a lack of power to any number of indoor units shall not be acceptable or allowed.
 - c. Main microprocessor shall include human interface capability that provides a visual code that reports systems operation status. If any malfunction occurs, or system is operating with an unstable refrigerant cycle sensors shall report the malfunction to the visual display.
 - d. Main processor shall provide the commissioning agent the ability to customize the VRF systems operation based on the environment in which it is installed. Customization function to include defrost operation, modifying target superheat, sub-cooling, low pressure and high pressure values , and invoke other algorithms such as smart load control to optimize system operating efficiency. The main processor board shall include the following features:
 - 1) Service tool connection
 - 2) DIP switches

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- 3) Auto addressing
 - 4) Error codes
 - 5) Main microprocessor
 - 6) Inverter PCB
10. Outdoor unit microprocessor shall have the capability of reporting malfunction and diagnostic codes to remote control devices such as the VRF manufacturer's central controller, Zone controllers, and Building Management System (BMS).
11. Refrigerant Flow Control
- a. The refrigerant cycle operation core logic shall establish and maintain target evaporating temperature (T_e) to be constant in cooling mode and condensing temperature (T_c) constant in heating mode and maintain system stable operation while operating compressors across the range of environmental conditions guaranteeing continuous compressor operation. VRF system core logic shall be able to dynamically modify the target evaporator and condenser temperatures to maximize energy savings when system is operating at part load conditions.
 - b. Smart Load Control (SLC): Smart load control operation shall enhance energy savings and increase indoor comfort by monitoring the real time ambient temperature, real time weighted mean average building load, and the outdoor relative humidity (if enabled).
 - c. Smart load control shall be field selectable to optimize system operation for project location and building use. Smart Load Control field setting shall select one of three operating algorithms. The commissioning agent shall select at the time of commissioning and can be changed at any other time:
 - d. The Smart Load Control available settings shall:
 - 1) The system shall be influenced by any one of the chosen algorithm
 - 2) Off mode: Smart load control algorithm shall be in off mode
 - 3) Smooth mode: Smart Load control shall maximize energy savings. The rate of temperature change shall be insignificant.
 - 4) Normal Mode: Smart Load Control shall balance the rate of temperature change with energy consumed.
 - 5) Peak Mode: Smart Load shall quickly cool/heat the building. The energy consumption shall not be the priority in this mode.
 - e. For the first 20 minutes after the initial startup, the Smart Load Control will influence the outdoor unit operation for the chosen algorithm. This operation will be available at every start up.
 - f. After 20 minutes of compressor operation
 - 1) Smart Load control will maintain the chosen logic and system will operate with the same core logic.
 - g. Smart Load Control monitors two or three inputs:
 - 1) Weighted mean average building load
 - 2) Outdoor ambient dry bulb temperature

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- 3) Outdoor ambient relative humidity or indoor relative humidity (when enabled)
- h. Enhance energy savings
 - 1) Cooling Mode:
 - a) Smart Load Control raises the system target low pressure during off-peak operation.
 - b) Raising the operating low pressure shall reduce the compressor lift, reduce compressor's speed and power consumption.
 - 2) Heating Mode
 - a) Smart Load control shall lower the system target high pressure during off-peak heating operation.
 - b) Lowering the operating high pressure target shall reduce compressor lift, reduce compressor speed and power consumption.
 - c) Energy saved is in addition to the energy savings basic VRF load control provides.
- i. Increased indoor comfort
 - 3) Smart Load control shall use one (or two) sensors to measure changing outdoor weather conditions and shall prepare the VRF system to operate under the revised weather conditions. This operation shall be activated before the changed ambient conditions have an impact on indoor units.

E. Field Supplied Refrigerant Piping Design Parameters

1. The outdoor unit shall be capable of operating at an elevation difference of up to of 164 feet above or 131 feet below the lowest or highest indoor unit respectively without the requirement of field installed sub cooler or other forms of performance enhancing booster devices.
2. The outdoor unit shall be capable of operating with up to 984 equivalent length feet of interconnecting liquid line refrigerant pipe in the network.
3. The outdoor unit shall be capable of operating with up to 492 actual feet or 574 equivalent length feet of liquid line refrigerant pipe spanning between outdoor unit and farthest indoor unit.
4. The elevation difference between the highest and lowest indoor units shall not exceed 49 feet.
5. The piping system shall be designed with pipe expansion and contraction possibilities in mind. Required expansion devices shall be field designed, supplied and installed based on proper evaluation of the proposed piping design. In addition to these requirements, the piping system installation must conform to the VRF equipment manufacturer's published guidelines.
6. The installation of pipe hangers, supports, insulation, and in general the methods chosen to attach the pipe system to the structure must allow for expansion and contraction of the piping system and shall not interfere with that movement.

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F. Defrost Operations

1. Heat Pump

- a. The outdoor unit(s) shall be capable of auto defrost operation to melt accumulated frost off the outdoor unit heat exchanger. The defrost cycle control shall monitor the outdoor ambient temperature and outdoor unit heat exchanger surface temperature.
- b. The frequency of operating the defrost cycle shall be determined by the system's ability to maintain sufficient system head pressure to deliver comfortable warm air to the building.

2. Heat Recovery

- a. The outdoor unit(s) shall be capable of intelligent defrost operation to melt accumulated frost off the outdoor unit heat exchanger. The defrost cycle control shall monitor the outdoor ambient temperature, humidity (if enabled), building load, and outdoor unit heat exchanger surface temperature in real time.
- b. The frequency of operating the defrost cycle shall be determined by the system's ability to maintain sufficient system head pressure to deliver comfortable warm air to the building.
- c. The intelligent defrost algorithm shall be field selectable at the time of commissioning of the outdoor unit based on anticipated winter weather conditions. Intelligent defrost continuously calculates the dew point of the ambient air using the outdoor unit's temperature and humidity sensors (if enabled) and maintains the outdoor unit's coil surface temperature above the dew point delaying defrost operation while maintaining indoor space temperature.
- d. The intelligent defrost algorithm shall provide smart heating that will extend the system's heating operation and reduce the frequency of defrost cycles.

G. Oil Management

1. The system shall have an oil injection mechanism to ensure a consistent film of oil on all moving compressor parts.
2. The system shall be provided with a factory installed oil separator at the discharge port of the compressor and designed to separate, condense, and collect oil vapor from the discharge refrigerant gas and return oil to the sump of the compressor. The oil separator shall have no moving parts in the separation chamber.
3. The system oil return control algorithm shall operate every 8 hours at a minimum, for a 3-minute period. When activated, the algorithm shall operate the system with the reversing valve in the cooling position, open all electronic expansion valves at the indoor unit(s) and raise the compressor speed to flush oil back to the compressor.

H. Fan and Motor Assembly

1. 2 ton Heat Pump unit shall be equipped with one direct drive, variable speed, and axial flow fan with a horizontal air discharge. The motors shall be Brushless Digitally Controlled (BLDC), variable speed, inverter driven motors.

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2. 3 to 5 ton Heat Pumps shall be equipped with two direct drive variable speed axial flow fan(s) with a horizontal air discharge. Each fan shall be provided with an independent dedicated Brushless Digitally Controlled (BLDC), variable speed, inverter driven motors
3. The fan(s) blades shall be made of Acrylonitrile Butadiene Styrene (ABS) material.
4. The fan motor(s) shall be equipped with permanently lubricated bearings.
5. The fan assembly(s) shall have a minimum operating speed range from 0 RPM to 850 RPM in cooling mode and heating mode.
6. The fan(s) shall have a polymer fan guard(s) to help prevent contact with moving parts.
7. The fan control shall have a function setting to remove accumulated powder snow from outdoor fan blades and discharge fan guard

I. Cabinet

1. The cabinet shall have piping knockouts to allow refrigerant piping to be connected at the front, right side, or through the bottom of the unit.
2. The cabinet shall have a factory installed coil guard and shall have a baked enamel finish.
3. A removable service panel, shall be provided to access the following internal components:
 - a. Service tool connection
 - b. DIP switches
 - c. Main microprocessor
 - d. Inverter PCB
 - e. Outdoor unit coil EEV valve
 - f. Subcooling heat exchanger and EEV valve.
 - g. Reversing valve.

J. Outdoor Unit Coil

1. Outdoor unit coil shall be comprised of aluminum fins mechanically bonded to copper tubing with inner surfaces having a riffling treatment to expand the total surface of the tube interior
2. The aluminum fin heat transfer surfaces shall have factory applied corrosion resistant coating. The coils coating shall be tested per ASTM B-117 standard. The test shall be performed for a minimum of 1000 hours. The outdoor unit coil shall have a minimum of 2 rows.
3. The outdoor unit coil shall have a minimum of 14 Fins per Inch (FPI).
4. The outdoor unit coil, all indoor units and the interconnecting field provided pipe network shall be field tested to a minimum pressure of 550 psig. Manufacturers that do not specify and/or specify field testing pressures at less than 550 psig shall not be acceptable.

K. Compressor

1. Heat Pump models<ARUN024GSS4 ~ ARUN053GSS4>:

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- a. The compressor shall be a high efficiency high-side shell rotary hermetic design. Bearing shall be manufactured using high lubricity material. Compressor shall be factory charged with Polyvinyl Ether (PVE) oil. Single or dual speed compressors charged with Polyolester oil (POE) shall not be acceptable. Compressor inverter drive shall allow modulation from 20Hz to 90Hz with control in 1.0 Hz increments depending on the nominal capacity. <ARUN060GSS4> The compressor shall be a high-side shell hermetic scroll design. Oil sump area and chamber housing the motor shall be operated at the same temperature and pressure of the gas leaving the compressor chamber to ensure that the low temperature low pressure refrigerant returning to the compressor does not mix with the oil in the sump. Bearing shall be manufactured using high lubricity material. Compressor shall be factory charged with Polyvinyl Ether (PVE) oil. Single or dual speed compressors charged with Polyolester oil (POE) oil shall not be acceptable. Compressor motor shall be designed to operate at a frequency range of 0Hz to 160Hz. Compressor inverter drive shall allow modulation from 12Hz to 110Hz.

L. Operational Sound Levels

1. The compressor(s) shall be wrapped with heat resistant foil faced, sound deadening blanket that covers all exposed surfaces of the compressor. Sound deadening blankets shall be secured in place by use of a Velcro™ tool-less joint sealing system with a minimum of ½” of overlap along all seams. The sound deadening compressor blanket shall be engineered to leave no direct sound path between the outer surface of the body of the compressor and the surrounding environment.
2. The compressor(s) shall be mounted on rubber isolation grommets. Compressor shall ship with removable clamps that secure the compressor in place while transported. The installing contractor shall remove and discard (or optionally adjust the clamps to allow the isolator to properly function) the clamps prior to commissioning the water source unit.
3. Manufacturers’ published data shall include sound pressure and sound power levels.
 - a. Sound pressure level shall not exceed 57 dB(A) during cooling operation for Heat Pump and Heat Recovery outdoor units when tested in an anechoic chamber under ISO3745 standard. Other testing conditions shall not be allowed.
 - b. Sound power level shall not exceed 69 dB(A) when tested in an anechoic chamber under ISO3745 standard. Other testing conditions shall not be allowed.

M. Sensors

1. The outdoor unit shall have
 - a. Suction temperature sensor
 - b. Discharge temperature sensor
 - c. High Pressure sensor
 - d. Low Pressure sensor
 - e. Outdoor temperature sensor
 - f. Outdoor unit heat exchanger temperature sensors

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- N. Wind Load Installations for Outdoor Units
 - 1. LG FL Wind load Installation Drawings meet the requirements of the 2017 Florida Building Code, 6th Edition and ASCE Standard 7-2010

- O. Seismic Installations
 - 1. Provide OSHPD Special Seismic Certification Preapproval (OSP) documents for certified product list of VRF equipment to be installed in high seismic risk areas. Provide LG supplemental installation documents in conformance with CBC 2013, 2016 and 2019 California Building Code and IBC 2012, 2015 and 2018 International Building Code.

- P. Warranty
 - 1. Limited Warranty Period
 - a. STANDARD ONE-YEAR PARTS WARRANTY FOR A QUALIFIED SYSTEM - The Part(s) of a qualified System, including the compressor, are warranted for a period (the “Standard Parts Warranty Period”) ending on the earlier to occur of one (1) year after the date of original installation, or eighteen (18) months from the date of manufacture.
 - b. ADDITIONAL SIX (6) YEAR COMPRESSOR PART WARRANTY - The Compressor is warranted for an additional six (6) year period after the end of the applicable Standard Part Warranty Period (the “Compressor Warranty Period”).
 - 2. Extended Warranty
 - a. The Standard Warranty Period and the Compressor Warranty Period are extended to a total of ten (10) years (the “Extended Warranty Period”) for qualified Systems that have been (a) commissioned by a party that has completed the current Training Requirements, (b) such commissioning is pursuant to LG’s current published instructions, and (c) the System commissioning results and supporting documents are entered correctly into LG’s online commissioning system. Commissioning of a System requires one (1) hour of LG Monitoring View (LGMV) data. Commissioning results must be entered into LG’s online commissioning system within sixty (60) days of System startup.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

- B. Install compressor-condenser components on restrained, spring isolators with a minimum static deflection of 1 inch.

3.2 CONNECTIONS

- A. Connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.
- B. Connect supply and return refrigerant coil with valves as per Specification 23 8113.
- C. Connect supply and return condenser connections with valves as per Specification 23 8113.
- D. Install piping adjacent to unit to allow service and maintenance.

3.3 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing. Representative shall provide two 4-hour training sessions for the owner on separate days.
- B. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
- C. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Remove malfunctioning units, replace with new components, and retest.
- D. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

END OF SECTION

SECTION 26 0500 - COMMON WORK RESULTS FOR ELECTRICAL

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General Conditions, 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 Albuquerque, 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

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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

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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.

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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

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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:

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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.

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- 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.

PART 2 PRODUCTS

2.1 QUALITY OF MATERIALS

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

2.2 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.

2.3 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

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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.

PART 3 EXECUTION

3.1 COOPERATION WITH OTHER TRADES

- A. Coordinate all work so that the construction operations can proceed without harm to the Owner from interference, delay, or absence of coordination. The Contractor shall be responsible for the size and accuracy of all openings.

3.2 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.

3.3 ELECTRICAL INSTALLATIONS

- A. General: Sequence, coordinate, and integrate the various elements of electrical system, materials, and equipment. Comply with the following requirements:
 - 1. Coordinate electrical systems, equipment, and materials installation with all other building components.
 - 2. Verify all dimensions by field measurements.

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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.

3.4 FIELD MEASUREMENTS

- A. No extra compensation shall be claimed or allowed due to differences between actual dimensions, including dimensions of equipment, fixtures and materials furnished, and those indicated on the drawings. Contractor shall examine adjoining work, and shall report any work which must be corrected. Review of submittal data in accordance with paragraph "Submittals" shall in no manner relieve the Contractor of responsibility for the proper installation of the electrical work within the available space. Installation of equipment and systems within the building space shall be carefully coordinated by the Contractor.

3.5 EQUIPMENT SUPPORT

- A. Provide support for equipment to the building structure. Provide all necessary structures, inserts, sleeves, firestops and hanging devices for installation of equipment. Coordinate installation of devices. Verify with the Owner's Representative that the devices and supports are adequate as intended and do not overload the building's structural components in any way.

3.6 PROTECTION OF MATERIALS AND EQUIPMENT

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

3.7 EXCAVATION

- A. Provide all excavation, trenching and backfilling required.
- B. Slope sides of excavations to comply with codes and ordinances. Shore and brace as required for stability of excavation.

3.8 ERECTION OF METAL SUPPORTS AND ANCHORAGE

- A. Cut, fit, and place miscellaneous metal fabrications accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- B. Field Welding: Comply with AWS "Structural Welding Code."

3.9 ERECTION OF WOOD SUPPORTS AND ANCHORAGE

- A. Cut, fit, and place wood grounds, nailers, blocking, and anchorage accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- B. Select fastener sizes that will not penetrate members where opposite side will be exposed to view or will receive finish materials. Make tight connections between members. Install fasteners without splitting wood members.
- C. Attach to substrates as required to support applied loads.

3.10 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.

3.11 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.

3.12 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.

3.13 CONCRETE BASES AND HOUSEKEEPING PADS

- A. Install concrete bases and housekeeping pads under all freestanding electrical equipment unless otherwise noted.

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- 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.

3.14 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.

3.15 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.

3.16 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

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delivery of O&M manuals, spare parts required, and equipment warranties which shall be bound with O&M manuals.

3.17 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.

3.18 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

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DIVISION 26 SUBSTITUTION REQUEST FORM (SRF)

TO: BRIDGERS & PAXTON CONSULTING ENGINEERS

PROJECT: _____

We hereby submit for your consideration the following product instead of the specified item for the above project:

Section: _____ Page: _____ Paragraph/Line: _____ Specified Item: _____

Proposed Substitution: _____

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

1. Will changes be required to building design in order to properly install proposed substitutions? YES NO

If YES, explain: _____

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

3. List differences between proposed substitutions and specified item.

Specified Item	Proposed Substitution
_____	_____
_____	_____

4. Does substitution affect Drawing dimensions? YES NO

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

6. Does the manufacturer's warranty for proposed substitution differ from that specified? YES NO

If YES, explain: _____

7. Will substitution affect progress schedule? YES NO

If YES, explain: _____

8. Will maintenance and service parts be locally available for substitution? YES NO

If YES, explain: _____

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

SUBMITTED BY: Firm: _____ Date: _____

Address: _____

Signature: _____ Telephone: _____

For Engineer's Use Only

Accepted _____	Not Accepted _____	Received Too Late _____
By: _____	Date: _____	
Remarks: _____		

LICENSE AGREEMENT FOR CADD DATABASE OR BIM MODEL

PROJECT: _____

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

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

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

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

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

CONTRACTOR'S REPRESENTATIVE

Signature: _____ Company Name: _____

Name: _____ Address 1: _____

Title: _____ Address 2: _____

Date: _____

SECTION 26 0519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. 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.

PART 2 PRODUCTS

2.1 COPPER BUILDING WIRE

- A. Description: Flexible, insulated and uninsulated, drawn copper current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.
- B. Manufacturers: Subject to compliance with requirements, 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.

2.2 CONNECTORS AND SPLICES

- A. Description: Factory-fabricated connectors, splices, and lugs of size, ampacity rating, material, type, and class for application and service indicated; listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
- B. Manufacturers: Subject to compliance with requirements, 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.

PART 3 EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

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

3.2 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 Crawlspace: 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 Crawlspace: 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.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

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

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- 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."

3.4 **CONNECTIONS**

- A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.
- B. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
- C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches (150 mm) of slack.

3.5 **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.

3.6 **SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS**

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.7 **FIRESTOPPING**

- A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Section 078413 "Penetration Firestopping."

3.8 **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

SECTION 26 0526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes grounding and bonding systems and equipment, 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:

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- 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.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with UL 467 for grounding and bonding materials and equipment.

2.2 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Burndy; Part of Hubbell Electrical Systems.
 - 2. 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.

2.3 CONDUCTORS

- A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.
- B. Bare Copper Conductors:
 - 1. Solid Conductors: ASTM B 3.
 - 2. Stranded Conductors: ASTM B 8.
 - 3. 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.

2.4 CONNECTORS

- A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.
- B. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
- C. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless compression 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.

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- 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.

2.5 GROUNDING ELECTRODES

- A. Ground Rods: Copper-clad; 3/4 inch by 10 feet.
- B. Ground Plates: 1/4 inch thick, hot-dip galvanized.

PART 3 EXECUTION

3.1 APPLICATIONS

- A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.
- B. Underground Grounding Conductors: Install bare -copper conductor, No. 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.

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2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down; connect to horizontal bus.

E. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

3.2 GROUNDING AT THE SERVICE

- A. Equipment grounding conductors and grounding electrode conductors shall be connected to the ground bus. Install a main bonding jumper between the neutral and ground buses.

3.3 GROUNDING SEPARATELY DERIVED SYSTEMS

- A. Generator: Install grounding electrode(s) at the generator location. The electrode shall be connected to the equipment grounding conductor and to the frame of the generator.

3.4 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

- A. Comply with IEEE C2 grounding requirements.
- B. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches above to 6 inches below concrete. Seal floor opening with waterproof, nonshrink grout.

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.

3.5 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.

3.6 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.

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- 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.

3.7 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:

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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.

3.8 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

SECTION 26 0529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Steel slotted support systems.
 - 2. Aluminum slotted support systems.
 - 3. Nonmetallic slotted support systems.
 - 4. Conduit and cable support devices.
 - 5. Support for conductors in vertical conduit.
 - 6. Structural steel for fabricated supports and restraints.
 - 7. Mounting, anchoring, and attachment components, including powder-actuated fasteners, mechanical expansion anchors, concrete inserts, clamps, through bolts, toggle bolts, and hanger rods.
 - 8. Fabricated metal equipment support assemblies.
- B. Related Requirements:
 - 1. 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.

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- 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.

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2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Welding certificates.

1.5 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M.
- B. Welding Qualifications: Qualify procedures and personnel according to the following:
 1. AWS D1.1/D1.1M.
 2. AWS D1.2/D1.2M.

PART 2 PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design hanger and support system.
- B. Seismic Performance: Hangers and supports shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 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.

2.2 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

- A. Steel Slotted Support Systems: Preformed steel channels and angles with minimum 13/32-inch-diameter holes at a maximum of 8 inches 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.

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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.

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3. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
6. Toggle Bolts: All Stainless-steel springhead type.
7. Hanger Rods: Threaded steel.

2.3 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

- A. Description: Welded or bolted structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.
- B. Materials: Comply with requirements in Section 055000 "Metal Fabrications" for steel shapes and plates.

PART 3 EXECUTION

3.1 APPLICATION

- A. Comply with the following standards for application and installation requirements of hangers and supports, except where requirements on Drawings or in this Section are stricter:
 1. NECA 1.
 2. NECA 101
 3. NECA 102.
 4. NECA 105.
 5. NECA 111.
- B. Comply with requirements in Section 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.

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- F. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings, and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this article.
- B. Raceway Support Methods: In addition to methods described in NECA 1, EMT, 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.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

- A. Comply with installation requirements in Section 055000 "Metal Fabrications" for site-fabricated metal supports.

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- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- C. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 CONCRETE BASES

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

3.5 PAINTING

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 - 1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.
- B. Touchup: Comply with requirements in Section 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

SECTION 26 0533 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Metal conduits and fittings.
2. Nonmetallic conduits and fittings.
3. Metal wireways and auxiliary gutters.
4. Nonmetal wireways and auxiliary gutters.
5. Surface raceways.
6. Boxes, enclosures, and cabinets.
7. Handholes 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.

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- 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.

PART 2 PRODUCTS

2.1 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.

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- 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.

2.2 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.

2.3 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.

2.4 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.

2.5 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.

2.6 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.

2.7 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.

2.8 SOURCE QUALITY CONTROL FOR UNDERGROUND ENCLOSURES

- A. Handhole and Pull-Box Prototype Test: Test prototypes of handholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.
1. Tests of materials shall be performed by an independent testing agency.
 2. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
 3. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012 and traceable to NIST standards.

PART 3 EXECUTION

3.1 RACEWAY APPLICATION

- A. Outdoors: Apply raceway products as specified below unless otherwise indicated:
1. Exposed Conduit: GRC.
 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.

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- 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).

3.2 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:

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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:

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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.

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- 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.

3.3 INSTALLATION OF UNDERGROUND CONDUIT

- A. Direct-Buried Conduit:
 - 1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Section 312000 "Earth Moving" for pipe 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

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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."

3.4 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.

3.5 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.6 FIRESTOPPING

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

3.7 PROTECTION

- A. Protect coatings, finishes, and cabinets from damage and deterioration.

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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.

3.8 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 wire 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 3/4 inch wide tape in colors as

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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

SECTION 26 0543 - UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Metal conduits and fittings, including GRC and PVC-coated steel conduit.
 - 2. Rigid nonmetallic duct.
 - 3. 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.

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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.

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- 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.

PART 2 PRODUCTS

2.1 METAL CONDUIT AND FITTINGS

- A. GRC: Comply with ANSI C80.1 and UL 6.
- B. Coated Steel Conduit: PVC-coated GRC.
 - 1. Comply with NEMA RN 1.
 - 2. Coating Thickness: 0.040 inch, minimum.
- C. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.

2.2 RIGID NONMETALLIC DUCT

- A. Underground Plastic Utilities Duct: Type EPC-40-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.

2.3 DUCT ACCESSORIES

- A. Duct Spacers: Factory-fabricated, rigid, PVC interlocking spacers; sized for type and size of duct with which used, and selected to provide minimum duct spacing indicated while supporting duct during concreting or backfilling.
- B. Underground-Line Warning Tape: Comply with requirements for underground-line warning tape specified in Section 260553 "Identification for Electrical Systems."

2.4 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.

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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.

2.5 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.

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- 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.

2.6 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.

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

2.7 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.

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3. Testing machine pressure gages shall have current calibration certification, complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

PART 3 EXECUTION

3.1 PREPARATION

- A. Coordinate layout and installation of duct, duct bank, 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."

3.2 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.

3.3 UNDERGROUND ENCLOSURE APPLICATION

- A. Handholes and Boxes for 600 V and Less:
 1. Units in Roadways and Other Deliberate Traffic Paths: Precast concrete, AASHTO HB 17, H-20 structural load rating.
 2. Units in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Non-deliberate Loading by Heavy Vehicles: Precast concrete, AASHTO HB 17, H-20 structural load rating.

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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.

3.4 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."

3.5 DUCT AND DUCT-BANK INSTALLATION

- A. Where indicated on Drawings, install duct, spacers, and accessories into the duct-bank configuration shown. Duct installation requirements in this Section also apply to duct bank.
- B. Install duct according to NEMA TCB 2.
- C. Slope: Pitch duct a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope duct from a high point between two manholes, to drain in both directions.
- D. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius of 48 inches (1200 mm), both horizontally and vertically, at other locations unless otherwise indicated.
 1. *ASI 007 Duct shall have maximum of four 90 degree bends or the total of all bends shall be no more 360 degrees between pull points. ASI 007*
- 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.

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- 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 3 inches (75 mm) wider than duct on each side.

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3. 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.
4. Support duct on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.
5. *ASI 007 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. Secure spacers to earth and to duct to prevent floating during concreting. Tie entire assembly together using tie wires. ASI 007*
6. 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.
7. *ASI 007 Elbows: Use manufactured GRC elbows for stub-ups, at building entrances and stub-up into equipment. ASI 007*
 - 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.
8. 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.
9. 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.
10. 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.
11. 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

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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. *ASI 007 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. Secure spacers to earth and to ducts to prevent floating during concreting. Tie entire assembly together using tie wires. ASI 007*
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.
 - 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

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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.

3.6 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.

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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.

3.7 GROUNDING

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

3.8 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.

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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.

3.9 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

SECTION 26 0544 - SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors.
 - 2. Sleeve-seal systems.
 - 3. Sleeve-seal fittings.
 - 4. Grout.
 - 5. Silicone sealants.
- B. Related Requirements:
 - 1. Section 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.

PART 2 PRODUCTS

2.1 SLEEVES

- A. Wall Sleeves:
 - 1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.
 - 2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.
- B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.

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- C. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.
- D. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.
- E. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.
- F. Sleeves for Rectangular Openings:
 - 1. Material: Galvanized sheet steel.
 - 2. Minimum Metal Thickness:
 - a. For sleeve cross-section rectangle perimeter less than 50 inches and with no side larger than 16 inches, thickness shall be 0.052 inch.
 - b. For sleeve cross-section rectangle perimeter 50 inches or more and one or more sides larger than 16 inches, thickness shall be 0.138 inch.

2.2 SLEEVE-SEAL SYSTEMS

- A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
 - 1. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
 - 2. Pressure Plates: Carbon steel.
 - 3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.3 SLEEVE-SEAL FITTINGS

- A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber waterstop collar with center opening to match piping OD.

2.4 GROUT

- A. Description: 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.

2.5 SILICONE SEALANTS

- A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.
 - 1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.
- B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

PART 3 EXECUTION

3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

- A. Comply with NECA 1.
- B. Comply with NEMA VE 2 for cable tray and cable penetrations.
- C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:
 - 1. Interior Penetrations of Non-Fire-Rated Walls and Floors:
 - a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 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.

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- E. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.
- F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing sleeve-seal system.

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.
- B. Install type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.3 SLEEVE-SEAL-FITTING INSTALLATION

- A. Install sleeve-seal fittings in new walls and slabs as they are constructed.
- B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.
- C. Secure nailing flanges to concrete forms.
- D. Using grout, seal the space around outside of sleeve-seal fittings.

END OF SECTION

SECTION 26 0548.16 - SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. 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.

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- 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.

PART 2 PRODUCTS

2.1 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.

2.2 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.

2.3 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.

2.4 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.

2.5 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.

2.6 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.

PART 3 EXECUTION

3.1 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.

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- 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.

3.2 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.

3.3 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.

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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.

3.4 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.

3.5 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.

3.6 ADJUSTING

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

END OF SECTION

SECTION 26 0553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Color and legend requirements for raceways, conductors, and warning labels and signs.
 - 2. Labels.
 - 3. Bands and tubes.
 - 4. Tapes and stencils.
 - 5. Tags.
 - 6. Signs.
 - 7. Cable ties.
 - 8. Paint for identification.
 - 9. Fasteners for labels and signs.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for electrical identification products.
- B. Samples: For each type of label and sign to illustrate composition, size, colors, lettering style, mounting provisions, and graphic features of identification products.
- C. Identification Schedule: For each piece of electrical equipment and electrical system components to be an index of nomenclature for electrical equipment and system components used in identification signs and labels. Use same designations indicated on Drawings.
- D. Delegated-Design Submittal: For arc-flash hazard study.

PART 2 PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Comply with ASME A13.1.
- B. Comply with NFPA 70.
- C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.
- D. Comply with ANSI Z535.4 for safety signs and labels.
- E. Comply with NFPA 70E and Section 260574 "Overcurrent Protective Device Arc-Flash Study" requirements for arc-flash warning labels.
- F. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.
- G. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.
 - 1. Temperature Change: 120 deg F (67 deg C), ambient;

2.2 COLOR AND LEGEND REQUIREMENTS

- A. Raceways and Cables Carrying Circuits at 600 V or Less:
 - 1. Colored raceways are required. Refer to section 260533 for requirements.
 - 2. Black letters on an orange field.
 - 3. 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:

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- 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 or Green.
 7. Colors for Isolated Grounds: Green with white stripe.
- C. Raceways and Cables Carrying Circuits at More Than 600 V:
1. Black letters on an orange field.
 2. Legend: "DANGER - CONCEALED HIGH VOLTAGE WIRING."
- D. Warning Label Colors:
1. Identify system voltage with black letters on an orange background.
- E. Warning labels and signs shall include, but are not limited to, the following legends:
1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
 2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES (915 MM)."
- F. Equipment Identification Labels:
1. Black letters on a white field.

2.3 LABELS

- A. Vinyl Wraparound Labels: Preprinted, flexible labels laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.
- 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.
- C. Self-Adhesive Wraparound Labels: Preprinted, 3-mil- (0.08-mm-) thick, polyester or vinyl flexible label with acrylic pressure-sensitive adhesive.
1. 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.
 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.

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- D. Self-Adhesive Labels: Polyester, thermal, transfer-printed, 3-mil- (0.08-mm-) thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.
 - 1. Minimum Nominal Size:
 - a. 1-1/2 by 6 inches (37 by 150 mm)for raceway and conductors.
 - b. 3-1/2 by 5 inches (76 by 127 mm)for equipment.
 - c. As required by authorities having jurisdiction.

2.4 BANDS AND TUBES

- A. Snap-around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inches (50 mm) long, with diameters sized to suit diameters and that stay in place by gripping action.
- 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 (93 deg C). Comply with UL 224.

2.5 TAPES AND STENCILS

- A. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.
- B. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; not less than 3 mils (0.08 mm) thick by 1 to 2 inches (25 to 50 mm) wide; compounded for outdoor use.
- C. Tape and Stencil: 4-inch- (100-mm-) wide black stripes on 10-inch (250-mm) centers placed diagonally over orange background and is 12 inches (300 mm) wide. Stop stripes at legends.
- D. Floor Marking Tape: 2-inch- (50-mm-) wide, 5-mil (0.125-mm) pressure-sensitive vinyl tape, with black and white stripes and clear vinyl overlay.
- E. Underground-Line Warning Tape:
 - 1. 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.
 - 2. 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".

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- c. Inscriptions for Orange-Colored Tapes: "TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE".
- F. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height shall be 1 inch (25 mm).

2.6 TAGS

- A. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch (50 by 50 by 1.3 mm), with stamped legend, punched for use with self-locking cable tie fastener.
- B. Nonmetallic Preprinted Tags: Polyethylene tags, 0.015 inch (0.38 mm) thick, color-coded for phase and voltage level, with factory screened permanent designations; punched for use with self-locking cable tie fastener.
- C. Write-on Tags:
 - 1. Polyester Tags: 0.010 inch (0.25 mm) thick, with corrosion-resistant grommet and cable tie for attachment.
 - 2. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
 - 3. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.7 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 (6.4-mm) grommets in corners for mounting.
 - 3. Nominal Size: 7 by 10 inches (180 by 250 mm).
- B. Metal-Backed Butyrate Signs:
 - 1. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs, with 0.0396-inch (1-mm) galvanized-steel backing, punched and drilled for fasteners, and with colors, legend, and size required for application.
 - 2. 1/4-inch (6.4-mm) grommets in corners for mounting.
 - 3. Nominal Size: 10 by 14 inches (250 by 360 mm).
- C. Laminated Acrylic or Melamine Plastic Signs:
 - 1. Engraved legend.
 - 2. Thickness:
 - a. For signs up to 20 sq. in. (129 sq. cm), minimum 1/16 inch (1.6 mm) thick.
 - b. For signs larger than 20 sq. in. (129 sq. cm), 1/8 inch (3.2 mm) thick.

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- 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.

2.8 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 (5 mm).
 - 2. Tensile Strength at 73 Deg F (23 Deg C) according to ASTM D 638: 12,000 psi (82.7 MPa).
 - 3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
 - 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 (5 mm).
 - 2. Tensile Strength at 73 Deg F (23 Deg C) according to ASTM D 638: 12,000 psi (82.7 MPa).
 - 3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
 - 4. Color: Black.
- C. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, and self-locking.
 - 1. Minimum Width: 3/16 inch (5 mm).
 - 2. Tensile Strength at 73 Deg F (23 Deg C) according to ASTM D 638: 7000 psi (48.2 MPa).
 - 3. UL 94 Flame Rating: 94V-0.
 - 4. Temperature Range: Minus 50 to plus 284 deg F (Minus 46 to plus 140 deg C).
 - 5. Color: Black.

2.9 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).
- B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 EXECUTION

3.1 PREPARATION

- A. Self-Adhesive Identification Products: Before applying electrical identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

3.2 INSTALLATION

- A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.
- B. Install identifying devices before installing acoustical ceilings and similar concealment.
- C. Verify identity of each item before installing identification products.
- D. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.
- E. Apply identification devices to surfaces that require finish after completing finish work.
- F. Install signs with approved legend to facilitate proper identification, operation, and maintenance of electrical systems and connected items.
- G. System Identification for Raceways and Cables under 600 V: Identification shall completely encircle cable or conduit. Place identification of two-color markings in contact, side by side.
 - 1. Secure tight to surface of conductor, cable, or raceway.
- H. System Identification for Raceways and Cables over 600 V: Identification shall completely encircle cable or conduit. Place adjacent identification of two-color markings in contact, side by side.
 - 1. Secure tight to surface of conductor, cable, or raceway.
- I. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.
- J. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch- (10-mm-) high letters for emergency instructions at equipment used for power transfer and load shedding.
- K. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from the floor.

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- L. Accessible Fittings for Raceways: Identify the covers of each junction and pull box of the following systems with the wiring system legend and system voltage. System legends shall be as follows:
 - 1. "EMERGENCY POWER."
 - 2. "POWER."
 - 3. "UPS."
- M. Vinyl Wraparound Labels:
 - 1. Secure tight to surface of raceway or cable at a location with high visibility and accessibility.
 - 2. Attach labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to the location and substrate.
- N. Snap-around Labels: Secure tight to surface at a location with high visibility and accessibility.
- O. Self-Adhesive Wraparound Labels: Secure tight to surface at a location with high visibility and accessibility.
- P. Self-Adhesive Labels:
 - 1. On each item, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual.
 - 2. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high label; where two lines of text are required, use labels 2 inches (50 mm) high.
- Q. Snap-around Color-Coding Bands: Secure tight to surface at a location with high visibility and accessibility.
- R. Heat-Shrink, Preprinted Tubes: Secure tight to surface at a location with high visibility and accessibility.
- S. Marker Tapes: Secure tight to surface at a location with high visibility and accessibility.
- T. Self-Adhesive Vinyl Tape: Secure tight to surface at a location with high visibility and accessibility.
 - 1. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches (150 mm) where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding.
- U. Tape and Stencil: Comply with requirements in painting Sections for surface preparation and paint application.
- V. Floor Marking Tape: Apply stripes to finished surfaces following manufacturer's written instructions.
- W. Underground Line Warning Tape:

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1. During backfilling of trenches, install continuous underground-line warning tape directly above cable or raceway at 6 to 8 inches (150 to 200 mm) below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches (400 mm) overall.
 2. Limit use of underground-line warning tape to direct-buried cables.
 3. Install underground-line warning tape for direct-buried cables and cables in raceways.
- X. Metal Tags:
1. Place in a location with high visibility and accessibility.
 2. Secure using general-purpose cable ties.
- Y. Nonmetallic Preprinted Tags:
1. Place in a location with high visibility and accessibility.
 2. Secure using general-purpose cable ties.
- Z. Write-on Tags:
1. Place in a location with high visibility and accessibility.
 2. Secure using general-purpose cable ties.
- AA. Baked-Enamel Signs:
1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
 2. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on minimum 1-1/2-inch- (38-mm-) high sign; where two lines of text are required, use signs minimum 2 inches (50 mm) high.
- BB. Metal-Backed Butyrate Signs:
1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
 2. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high sign; where two lines of text are required, use labels 2 inches (50 mm) high.
- CC. Laminated Acrylic or Melamine Plastic Signs:
1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
 2. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high sign; where two lines of text are required, use labels 2 inches (50 mm) high.
- DD. Cable Ties: General purpose, for attaching tags, except as listed below:
1. Outdoors: UV-stabilized nylon.
 2. In Spaces Handling Environmental Air: Plenum rated.

3.3 IDENTIFICATION SCHEDULE

- A. REFER TO SECTION 260533 FOR IDENTIFICATION OF EXPOSED OR ACCESSIBLE RACEWAYS.
- B. 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.
- C. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations of high visibility. Identify by system and circuit designation.
- D. Concealed Raceways, Duct Banks, more than 600 V, within Buildings: Tape and stencil. Stencil legend "DANGER - CONCEALED HIGH-VOLTAGE WIRING" with 3-inch- (75-mm-) high, black letters on 20-inch (500-mm) centers.
 - 1. Locate identification at changes in direction, at penetrations of walls and floors, and at 10-foot (3-m) maximum intervals.
- E. Accessible Raceways More Than 600 V: Vinyl wraparound labels.
 - 1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot (15-m) maximum intervals in straight runs, and at 25-foot (7.6-m) maximum intervals in congested areas.
- F. Accessible Raceways 600 V or Less: See section 260533.
 - 1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot (15-m) maximum intervals in straight runs, and at 25-foot (7.6-m) maximum intervals in congested areas.
- G. 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."
- H. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use vinyl wraparound labels to identify the phase.
 - 1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot (15-m) maximum intervals in straight runs, and at 25-foot (7.6-m) maximum intervals in congested areas.
- I. Power-Circuit Conductor Identification, More Than 600 V: For conductors in vaults, pull and junction boxes, manholes, and handholes, use nonmetallic preprinted tags colored and marked to indicate phase, and a separate tag with the circuit designation. Indicate upstream/downstream next equipment connection or manhole number.

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- J. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes, manholes, and handholes, use self-adhesive labels with the conductor or cable designation, origin, and destination.
- K. Control-Circuit Conductor Termination Identification: For identification at terminations, provide self-adhesive labels with the conductor designation.
- L. Conductors to Be Extended in the Future: Attach write-on tags to conductors and list source.
- M. Auxiliary Electrical Systems Conductor Identification: Self-adhesive vinyl tape that is uniform and consistent with system used by manufacturer for factory-installed connections.
 - 1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
- N. Locations of Underground Lines: Underground-line warning tape for power, lighting, communication, and control wiring and optical-fiber cable.
- O. 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 (300 mm) 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.
- P. Workspace Indication: Apply floor marking tape to finished surfaces. Show working clearances in the direction of access to live parts. Workspace shall comply with NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.
- Q. Instructional Signs: Self-adhesive labels, including the color code for grounded and ungrounded conductors.
- R. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive labels.
 - 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.
- S. Arc Flash Warning Labeling: Self-adhesive labels.
- T. Operating Instruction Signs: Self-adhesive labels.

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- U. Emergency Operating Instruction Signs: Self-adhesive labels with white legend on a red background with minimum 3/8-inch- (10-mm-) high letters for emergency instructions at equipment used for power transfer and load shedding.

- V. Equipment Identification Labels:
 - 1. Indoor Equipment: Laminated acrylic or melamine plastic sign.
 - 2. Outdoor Equipment: Laminated acrylic or melamine sign and Stenciled legend 4 inches (100 mm) 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 an 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. All receptacles and power outlets.

END OF SECTION

SECTION 26 0572 - OVERCURRENT PROTECTIVE DEVICE SHORT-CIRCUIT STUDY

PART 1 GENERAL

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

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submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.

- b. Revised single-line diagram, reflecting field investigation results and results of short-circuit study.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Short-Circuit Study Specialist.
- B. Product Certificates: For short-circuit study software, certifying compliance with IEEE 399.

1.6 QUALITY ASSURANCE

- A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are unacceptable.
- B. Short-Circuit Study Software Developer Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.
 1. The computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.
- C. Short-Circuit Study Specialist Qualifications: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.
- D. Field Adjusting Agency Qualifications: An independent agency, with the experience and capability to adjust overcurrent devices and to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

PART 2 PRODUCTS

2.1 COMPUTER SOFTWARE

- A. Manufacturers: Subject to compliance with requirements, provide products by 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.

2.2 SHORT-CIRCUIT STUDY REPORT CONTENTS

- A. Executive summary.
- B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of the computer printout.
- C. One-line diagram, showing the following:
 - 1. Protective device designations and ampere ratings.
 - 2. Cable size and lengths.
 - 3. Transformer kilovolt ampere (kVA) and voltage ratings.
 - 4. Motor and generator designations and kVA ratings.
 - 5. Switchgear, switchboard, motor-control center, and panelboard designations.
- D. Comments and recommendations for system improvements, where needed.
- E. Protective Device Evaluation:
 - 1. Evaluate equipment and protective devices and compare to short-circuit ratings.
 - 2. Tabulations of circuit breaker, fuse, and other protective device ratings versus calculated short-circuit duties.
 - 3. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
 - 4. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in the standards to 1/2-cycle symmetrical fault current.
 - 5. Verify adequacy of phase conductors at maximum three-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure that short-circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
- F. Short-Circuit Study Input Data: As described in "Power System Data" Article in the Evaluations.
- G. Short-Circuit Study Output:
 - 1. Low-Voltage Fault Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
 - a. Voltage.
 - b. Calculated fault-current magnitude and angle.
 - c. Fault-point X/R ratio.
 - d. Equivalent impedance.

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2. Momentary Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
 - a. Voltage.
 - b. Calculated symmetrical fault-current magnitude and angle.
 - c. Fault-point X/R ratio.
 - d. Calculated asymmetrical fault currents:
 - 1) Based on fault-point X/R ratio.
 - 2) Based on calculated symmetrical value multiplied by 1.6.
 - 3) Based on calculated symmetrical value multiplied by 2.7.
3. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
 - a. Voltage.
 - b. Calculated symmetrical fault-current magnitude and angle.
 - c. Fault-point X/R ratio.
 - d. No AC Decrement (NACD) ratio.
 - e. Equivalent impedance.
 - f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
 - g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Obtain all data necessary for the conduct of the study.
 1. Verify completeness of data supplied on the one-line diagram. Call any discrepancies to the attention of Architect.
 2. For equipment provided that is Work of this Project, use characteristics submitted under the provisions of action submittals and information submittals for this Project.
- B. Gather and tabulate the following input data to support the short-circuit study. Comply with recommendations in IEEE 551 as to the amount of detail that is required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.
 1. Product Data for Project's overcurrent protective devices involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
 2. Obtain electrical power utility impedance at the service.

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3. Power sources and ties.
4. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
5. For reactors, provide manufacturer and model designation, voltage rating, and impedance.
6. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip, SCCR, current rating, and breaker settings.
7. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
8. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
9. Motor horsepower and NEMA MG 1 code letter designation.
10. Cable sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).

3.2 SHORT-CIRCUIT STUDY

- A. Perform study following the general study procedures contained in IEEE 399.
- B. Calculate short-circuit currents according to IEEE 551.
- C. Base study on the device characteristics supplied by device manufacturer.
- D. The extent of the electrical power system to be studied is indicated on Drawings.
- E. Begin short-circuit current analysis at the service, extending down to the system overcurrent protective devices as follows:
 1. To normal system low-voltage load buses where fault current is 10 kA or less.
 2. Exclude equipment rated 240-V ac or less when supplied by a single transformer rated less than 125 kVA.
- F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.
- G. The calculations shall include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and shall apply to low- and medium-voltage, three-phase ac systems. The calculations shall also account for the fault-current dc decrement, to address the asymmetrical requirements of the interrupting equipment.
 1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.
- H. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault at each of the following:
 1. Electric utility's supply termination point.

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2. Incoming switchgear.
3. Unit substation primary and secondary terminals.
4. Low-voltage switchgear.
5. Motor-control centers.
6. Control panels.
7. Standby generators and automatic transfer switches.
8. Branch circuit panelboards.
9. Disconnect switches.

3.3 ADJUSTING

- A. Make minor modifications to equipment as required to accomplish compliance with short-circuit study.

3.4 DEMONSTRATION

- A. Train Owner's operating and maintenance personnel in the use of study results.

END OF SECTION

SECTION 26 0573 - OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes computer-based, overcurrent protective device coordination studies to determine overcurrent protective devices and to determine overcurrent protective device settings for selective tripping.
- 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.

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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.

PART 2 PRODUCTS

2.1 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.

2.2 PROTECTIVE DEVICE COORDINATION STUDY REPORT CONTENTS

- A. Executive summary.
- B. Study descriptions, purpose, basis and scope. Include case descriptions, definition of terms and guide for interpretation of the computer printout.
- C. One-line diagram, showing the following:
 - 1. Protective device designations and ampere ratings.
 - 2. Cable size and lengths.
 - 3. Transformer kilovolt ampere (kVA) and voltage ratings.
 - 4. Motor and generator designations and kVA ratings.

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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.

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- e. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves.
 - f. Cables and conductors damage curves.
 - g. Ground-fault protective devices.
 - h. Motor-starting characteristics and motor damage points.
 - i. Generator short-circuit decrement curve and generator damage point.
 - j. The largest feeder circuit breaker in each motor-control center and panelboard.
- 5. Series rating on equipment allows the application of two series interrupting devices for a condition where the available fault current is greater than the interrupting rating of the downstream equipment. Both devices share in the interruption of the fault and selectivity is sacrificed at high fault levels. Maintain selectivity for tripping currents caused by overloads.
 - 6. Provide adequate time margins between device characteristics such that selective operation is achieved.
 - 7. Comments and recommendations for system improvements.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Devices to be coordinated are indicated on Drawings.
 - 1. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.

3.2 PROTECTIVE DEVICE COORDINATION STUDY

- A. Comply with IEEE 242 for calculating short-circuit currents and determining coordination time intervals.
- B. Comply with IEEE 399 for general study procedures.
- C. The study shall be based on the device characteristics supplied by device manufacturer.
- D. The extent of the electrical power system to be studied is indicated on Drawings.
- E. Begin analysis at the service, extending down to the system overcurrent protective devices as follows:
 - 1. To normal system low-voltage load buses where fault current is 10 kA or less.
 - 2. Exclude equipment rated 240-V ac or less when supplied by a single transformer rated less than 125 kVA.

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- 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.

3.3 LOAD-FLOW AND VOLTAGE-DROP STUDY

- A. Perform a load-flow and voltage-drop study to determine the steady-state loading profile of the system. Analyze power system performance two times as follows:
1. Determine load-flow and voltage drop based on full-load currents obtained in "Power System Data" Article.
 2. Determine load-flow and voltage drop based on 80 percent of the design capacity of the load buses.
 3. Prepare the load-flow and voltage-drop analysis and report to show power system components that are overloaded, or might become overloaded; show bus voltages that are less than as prescribed by NFPA 70.

3.4 MOTOR-STARTING STUDY

- A. Perform a motor-starting study to analyze the transient effect of the system's voltage profile during motor starting. Calculate significant motor-starting voltage profiles and analyze the effects of the motor starting on the power system stability.
- B. Prepare the motor-starting study report, noting light flicker for limits proposed by IEEE 141, voltage sags so as not to affect the operation of other utilization equipment on the system supplying the motor.

3.5 POWER SYSTEM DATA

- A. Obtain all data necessary for the conduct of the overcurrent protective device study.
1. Verify completeness of data supplied in the one-line diagram on Drawings. Call discrepancies to the attention of Architect.
 2. For new equipment, use characteristics submitted under the provisions of action submittals and information submittals for this Project.
 3. For existing equipment, whether or not relocated obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers. The qualifications of technicians and engineers shall be qualified as defined by NFPA 70E.
- B. Gather and tabulate the following input data to support coordination study. The list below is a guide. Comply with recommendations in IEEE 551 for the amount of detail required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the

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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.

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- e. Ratings, types, and settings of utility company's overcurrent protective devices.
- f. Special overcurrent protective device settings or types stipulated by utility company.
- g. Time-current-characteristic curves of devices indicated to be coordinated.
- h. Manufacturer, frame size, interrupting rating in amperes rms symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
- i. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
- j. Panelboards, switchboards, motor-control center ampacity, and SCCR in amperes rms symmetrical.
- k. Identify series-rated interrupting devices for a condition where the available fault current is greater than the interrupting rating of the downstream equipment. Obtain device data details to allow verification that series application of these devices complies with NFPA 70 and UL 489 requirements.

3.6 FIELD ADJUSTING

- A. 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.

3.7 DEMONSTRATION

- A. Engage the Coordination Study Specialist to train Owner's maintenance personnel in the following:
 - 1. Acquaint personnel in the fundamentals of operating the power system in normal and emergency modes.
 - 2. Hand-out and explain the objectives of the coordination study, study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpreting the time-current coordination curves.
 - 3. Adjust, operate, and maintain overcurrent protective device settings.

END OF SECTION

SECTION 26 0574 - OVERCURRENT PROTECTIVE DEVICE ARC-FLASH STUDY

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes a computer-based, arc-flash study to determine the arc-flash hazard distance and the incident energy to which personnel could be exposed during work on or near electrical equipment.

1.3 DEFINITIONS

- A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.
- B. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.
- C. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.
- D. SCCR: Short-circuit current rating.
- E. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

1.4 ACTION SUBMITTALS

- A. Product Data: For computer software program to be used for studies.
- B. Study Submittals: Submit the following submittals after the approval of system protective devices submittals. Submittals shall be in digital form.
 - 1. Arc-flash study input data, including completed computer program input data sheets.
 - 2. Arc-flash study report; signed, dated, and sealed by a qualified professional engineer.
 - a. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary

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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.

PART 2 PRODUCTS

2.1 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.

2.2 ARC-FLASH STUDY REPORT CONTENT

- A. Executive summary.
- B. Study descriptions, purpose, basis and scope.
- C. One-line diagram, showing the following:
 - 1. Protective device designations and ampere ratings.
 - 2. Cable size and lengths.
 - 3. Transformer kilovolt ampere (kVA) and voltage ratings.
 - 4. Motor and generator designations and kVA ratings.
 - 5. Switchgear, switchboard, motor-control center and panelboard designations.
- D. Study Input Data: As described in "Power System Data" Article.
- E. Short-Circuit Study Output: As specified in "Short Circuit Study Output" Paragraph in "Short-Circuit Study Report Contents" Article in Section 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.

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- d. No AC Decrement (NACD) ratio.
 - e. Equivalent impedance.
 - f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
 - g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.
- H. Incident Energy and Flash Protection Boundary Calculations:
- 1. Arcing fault magnitude.
 - 2. Protective device clearing time.
 - 3. Duration of arc.
 - 4. Arc-flash boundary.
 - 5. Working distance.
 - 6. Incident energy.
 - 7. Hazard risk category.
 - 8. Recommendations for arc-flash energy reduction.
- I. Fault study input data, case descriptions, and fault-current calculations including a definition of terms and guide for interpretation of the computer printout.

2.3 ARC-FLASH WARNING LABELS

- A. Comply with requirements in Section 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.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Examine Project overcurrent protective device submittals. Proceed with arc-flash study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to arc-flash study may not be used in study.

3.2 ARC-FLASH HAZARD ANALYSIS

- A. Comply with NFPA 70E and its Annex D for hazard analysis study.
- B. Preparatory Studies:
 - 1. Short-Circuit Study Output: As specified in "Short-Circuit Study Output" Paragraph in "Short-Circuit Study Report Contents" Article in Section 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.

3.3 POWER SYSTEM DATA

- A. Obtain all data necessary for the conduct of the arc-flash hazard analysis.
 1. Verify completeness of data supplied on the one-line diagram on Drawings. 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.

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13. Motor horsepower and NEMA MG 1 code letter designation.
14. Low-voltage cable sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).
15. Medium-voltage cable sizes, lengths, conductor material, and cable construction and metallic shield performance parameters.

3.4 LABELING

- A. Apply one arc-flash label for 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.

3.5 APPLICATION OF WARNING LABELS

- A. Install the arc-fault warning labels under the direct supervision and control of the Arc-Flash Study Specialist.

3.6 DEMONSTRATION

- A. Engage the Arc-Flash Study Specialist to train Owner's maintenance personnel in the potential arc-flash hazards associated with working on energized equipment and the significance of the arc-flash warning labels.

END OF SECTION

SECTION 26 0800 - ELECTRICAL FACILITY STARTUP/COMMISSIONING

PART 1 GENERAL

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. Engage and pay for the services of a recognized 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.

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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.

PART 2 PRODUCTS

Not Applicable.

PART 3 EXECUTION

3.1 WORK PRIOR TO COMMISSIONING

- A. Complete all phases of work so the system can be tested, adjusted, and energized. Division 26 has primary start-up responsibilities with obligations to complete systems, including all sub-systems so they are fully functional and ready for testing and startup. This includes the complete installation of all equipment, materials, conduit, wire, supports, controls, etc., per the contract documents and related directives, clarifications, change orders, etc.

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- B. A commissioning plan will be developed by the CA and approved by the commissioning team. Division 26 is obligated to assist the CA in preparing the commissioning plan by providing all necessary information pertaining to the actual equipment and installation. If system modifications/clarifications are in the contractual requirements of this and related sections of work, they will be made at no additional cost to the Owner. If Contractor initiated system changes have been made that alter the commissioning process, notify the Commissioning Authority and Contract Administrator for approval.
- C. Specific pre-commissioning responsibilities of Division 26 are as follows:
 - 1. Bring each system to a fully construction completed state.
 - 2. Commissioning is intended to begin upon completion of a system. To support Partial Occupancy commissioning may proceed prior to the completion of systems, or sub-systems, and will be coordinated with the CA as equipment Early Run. Start of commissioning before system completion will not relieve Division 26 from completing those systems as per the schedule.

3.2 PARTICIPATION IN COMMISSIONING

- A. Provide skilled technicians to start up all systems within Division 26. These same technicians shall be made available to assist the CA in completing the commissioning program as it relates to each system and their technical specialty. Work schedules, time required for testing, etc., will be requested, coordinated by the CA, and tracked on the Commissioning Matrix. Division 26 will ensure that the qualified technician(s) are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustment, and/or problem resolutions.
- B. System problems and discrepancies may require additional technician time or reconstruction of systems and system components. The additional technician time shall be made available for the subsequent commissioning periods until the required system performance is obtained.
- C. The Contract Administrator and CA reserve the right to judge the appropriateness and qualifications of the technicians relative to each item of equipment or system. Qualifications of technicians include expert knowledge relative to the specific equipment involved, adequate documentation and tools to service/commission the equipment, and an attitude/willingness to work with the commissioning team to complete the job.

3.3 WORK TO RESOLVE DEFICIENCIES

- A. In some systems, misadjustment, misapplied equipment and/or deficient performance under varying loads will result in additional work being required to commission the systems. This work will be completed under the direction of the Contract Administrator, with input from the Contractor, equipment supplier, and CA. Whereas all members will have input and the opportunity to discuss the work and resolve problems, the Contract Administrator will have final jurisdiction on the necessary work to be done to achieve performance.
- B. Corrective work shall be completed in a timely fashion to permit completion of the commissioning process according to the schedule. Experimentation to render system performance will be permitted. If the CA deems the experimentation work to be ineffective or

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untimely as it relates to the commissioning process, the CA will notify the Owner indicating the nature of the problem, expected steps to be taken, and the deadline for completion of activities. If deadlines pass without resolution of the problem, the Owner reserves the right to obtain supplementary services and/or equipment to resolve the problem. Costs incurred to solve the problems in an expeditious manner will be the Contractor's responsibility.

3.4 TRAINING

- A. Participate in the training of the Owner's engineering and maintenance staff, as required in Divisions 26, on each system and related components. Training, in part, will be conducted in a classroom setting, with system and component documentation, and suitable classroom training aids.
- B. Training will be conducted by the Contractor and the equipment vendors.
- C. Training for the Commissioning Team members on the Commissioning Plan will be provided by the CA. All Commissioning Team members are required to attend this training.

3.5 SYSTEMS DOCUMENTATION

- A. In addition to the requirements of Division 26, update contract documents to incorporate field changes and revisions to system designs to account for actual constructed configurations. Red-line all drawings on two sets. Include architectural floor plans, elevations and details, and the individual electrical systems in relation to actual building layout in Division 26 as-built drawings.
- B. Maintain as-built red-lines as required by Division 1. Given the size and complexity of this project, red-line drawings at completion of construction, based on memory of key personnel, is not satisfactory. Continuous and regular red-lining of drawings is considered essential and mandatory. Maintain these drawings in the construction trailer and make them available for inspection at any time.

3.6 MISCELLANEOUS SUPPORT

- A. Division 26 shall remove and replace covers of equipment, open access panels, etc., to permit Contractor, Contract Administrator, or CA to observe equipment and controllers provided.

END OF SECTION

SECTION 26 0880 - ELECTRICAL ACCEPTANCE TESTING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplemental General Conditions and Division 1 Specification Sections, apply to this Section.
- B. Refer to individual specification sections indicated below for tests to be performed and additional requirements.

1.2 QUALITY ASSURANCE

- A. 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 non-serviceability 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.

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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
260513	Medium Voltage Cables
261219	Pad Mounted, Liquid Filled, Medium Voltage Transformers
261329	Medium-Voltage Compartmentalized Switchgear
262413	Switchboards
260573.16	Coordination Studies (Note 1)
260526	Grounding and Bonding of Electrical Systems
261323	Medium Voltage, Metal Enclosed Switchgear
262213	Low Voltage Distribution Transformers
263213.13	Diesel Emergency (Standby) Engine Generators
263600	Transfer Switches

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.

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

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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:

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- 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.

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- 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."

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.1 GENERAL

- A. Set all adjustable circuit breaker trip settings in accordance with the trip setting report from the COORDINATION 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.

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- C. Perform acceptance tests and inspections prior to energizing equipment, unless where energization is required to perform specified tests.
- D. Final acceptance will not occur before completion of the electrical acceptance tests, inspections and calibrations specified in this Section.

3.2 FIELD QUALITY CONTROL

- A. Standards: Comply with applicable standards of the InterNational Electrical Testing Association (NETA), including standard ATS.
- B. Acceptance Testing: After installing equipment and BEFORE electrical circuitry has been energized. Demonstrate product capability and compliance with requirements.

3.3 DIVISION OF RESPONSIBILITY

- A. The Electrical Testing Agency shall provide all material, equipment, labor and technical supervision to perform such tests and inspections as specified herein.
- B. The Electrical Testing Agency is responsible for programming all protective and alarming devices with the proper settings provided by the COORDINATION 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.

3.4 ACCEPTANCE TESTING PROCEDURES

- A. Testing and acceptance procedures for the equipment and systems listed in Part 1 shall be as described in the individual equipment specification sections listed above.

END OF SECTION

SECTION 26 0913 - ELECTRICAL POWER METERING SYSTEM

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Electrical Power Metering (EPM) will consist of interconnected power meters. Power meters to record energy / power usage / power quality will be located in each secondary switchboard (downstream of each site transformer), both at the main and feeder circuit breakers levels. Meters will be capable of communicating their data via BACnet. Meters shall interconnect with the Netflix Tridium Niagara Facility Management System (FMS). Meter manufacture shall assist in the integration of data points into the Netflix Tridium Niagara FMS. Refer to specification section 230900 for additional requirements.
- B. Section includes equipment and systems used to monitor and control electrical consumption:
 - 1. Power meters.
 - 2. Raceways and boxes.
 - 3. Wires and cables.
 - 4. Identification.

1.3 DEFINITIONS

- A. Active Power: The average power consumed by a unit. Also known as "real power."
- B. Analog: A continuously varying signal value, such as current, flow, pressure, or temperature.
- C. Apparent (Phasor) Power: " $S = VI$ " where "S" is the apparent power, "V" is the rms value of the voltage, and "I" is the rms value of the current.
- D. Firmware: Software (programs or data) that has been written onto read-only memory (ROM). Firmware is a combination of software and hardware. Storage media with ROMs that have data or programs recorded on them are firmware.
- E. KY Pulse: A method of measuring consumption of electricity that is based on a relay operating like a SPST switch.
- F. KYZ Pulse: A method of measuring consumption of electricity based on a relay operating like a SPDT switch.

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- G. LAN: Local area network.
- H. L-G: Line to ground.
- I. L-L: Line to line.
- J. L-N: Line to neutral.
- K. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or remote-control, signaling and power-limited circuits.
- L. Modbus TCP/IP: An open protocol for exchange of process data.
- M. Monitoring: Acquisition, processing, communication, and display of equipment status data, metered electrical parameter values, power quality evaluation data, event and alarm signals, tabulated reports, and event logs.
- N. N-G: Neutral to ground.
- O. Power Factor: The ratio of active power to apparent power, sometimes expressed in percentage.
- P. rms: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.
- Q. TCP/IP: Transport control protocol/Internet.
- R. UPS: Uninterruptible power supply; used both in singular and plural context.

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 power monitoring.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings: For power monitoring equipment.
 - 1. Include plans, elevations, sections, and attachment details.
 - 2. Include details of equipment assemblies. Indicate dimensions, method of field assembly, components, and location and size of each field connection.
 - a. Attach copies of approved Product Data submittals for products (such as switchboards, switchgear, and motor-control centers) that describe the following:
 - 1) Location of the meters and gateways, and routing of the connecting wiring.
 - 2) Details of power monitoring features to illustrate coordination among related equipment and power monitoring.
 - 3. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components. Indicate data

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communication paths and identify networks, data buses, data gateways, concentrators, and other devices to be used. Describe characteristics of network and other data communication lines.

4. Network naming and numbering scheme.
5. Include diagrams for power, signal, and control wiring. Coordinate nomenclature and presentation with a block diagram.
6. Specifications for workstations.
7. UPS sizing calculations for workstation.
8. Surge Suppressors: Data for each device used and where applied.

1.5 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.
- B. Design Data:
 1. Manufacturer's system installation and setup guides, with data forms to plan and record options and setup decisions.
 - a. Project Record Drawings of as-built versions of submittal Shop Drawings provided in electronic PDF format on compact disk or portable storage device with a USB interface.
 - b. Testing and commissioning reports and checklists of completed final versions of reports, checklists, and trend logs.
 - c. As-built versions of submittal Product Data.
 - d. Names, addresses, e-mail addresses, and 24-hour telephone numbers of Installer and service representatives for the system and products.
 - e. Operator's manual with procedures for operating control systems including logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing set points and variables.
 - f. Programming manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
 - g. Engineering, installation, and maintenance manuals that explain how to do the following:
 - 1) Design and install new points, panels, and other hardware.
 - 2) Perform preventive maintenance and calibration.
 - 3) Debug hardware problems.
 - 4) Repair or replace hardware.
 - h. Documentation of all programs created using custom programming language including set points, tuning parameters, and object database.
 - i. Backup copy of graphic files, programs, and database on compact disk or portable storage device with a USB interface.

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- j. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
- k. Complete original-issue copies of furnished software, including operating systems, custom programming language, workstation software, and graphics software on compact disk or portable storage device with a USB interface.
- l. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.
- m. Owner training materials.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For power monitoring units to include in operation and maintenance manuals.
- B. Software and Firmware Operational Documentation:
 - 1. Software operating and upgrade manuals.
 - 2. Software licenses.
 - 3. Software service agreement.
 - 4. PC installation and operating documentation, manuals, and software for the PC and all installed peripherals. Provide separately for each PC.
 - 5. Hard copies of manufacturer's specification sheets, operating specifications, design guides, user's guides for software and hardware, and PDF files on compact disk or portable storage device with a USB interface of the hard-copy submittal.
 - 6. Program Software Backup: On compact disk or portable storage device with a USB interface, complete with data files.
 - 7. Device address list.
 - 8. 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. Addressable Relays: One for every 10 installed. Furnish at least one of each type.
 - 2. Data Line Surge Suppressors: One for every 10 of each type installed. Furnish at least one of each type.

1.8 QUALITY ASSURANCE

- A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

1.9 COORDINATION

- A. Coordinate features of distribution equipment and power monitoring components to form an integrated interconnection of compatible components.
 - 1. Match components and interconnections for optimum performance of specified functions.
- B. Coordinate Work of this Section with those in Sections specifying distribution components that are monitored or controlled by power monitoring equipment.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Microprocessor-based monitoring of electrical power distribution system(s) that includes the following:
 - 1. Electrical meters that monitor and connect to the FMS data transmission network.
- 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. UL Compliance: Listed and labeled as complying with UL 61010-1.

2.2 PERFORMANCE REQUIREMENTS

- A. Surge Protection: For external wiring of each conductor entry connection to components to protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads.
 - 1. Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Lines: Comply with requirements as recommended by manufacturer for type of line being protected.
- B. Addressable Devices: All transmitters and receivers shall communicate unique device identification and status reports to monitoring clients.
- C. Backup Power Source:
 - 1. Electrical power distribution equipment served by a backup power source for controls shall have associated power monitoring system products that monitor and control such systems and equipment also served from a backup power source.

2.3 POWER METERS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. Eaton
 - 2. Schneider Electric USA, Inc.

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3. Siemens
- B. Description: Separately mounted, modular, permanently installed, solid-state, digital I/O instrument for power monitoring; complying with UL 61010-1.
1. Provide meter types / model numbers as indicated.
 2. Capable of metering 4-wire Y, 3-wire Y, 3-wire delta, and single-phase power systems.
 3. Equipped with security lock to protect revenue related metering from unauthorized and accidental changes.
- C. Environment: System components shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:
1. Indoor and outdoor.
 2. Comply with IEC 60529 degree of protection code of IP51 for the front of the meter, and code of IP30 for the body.
- D. Overvoltage: Comply with UL 61010-1 overvoltage withstand rating for CAT III.
- E. Accuracy:
1. Comply with ANSI C12.20, Class 0.5.
 2. Neutral Current Measurement: Not more than 0.65 percent.
 3. Power: 0.6 percent.
 4. Power Factor: 0.5 percent.
 5. Active Energy: 0.6 percent.
 6. Reactive Energy: 2.5 percent.
 7. Frequency: 0.05 percent.
 8. THD: 1.0 percent.
 9. Waveform Sampling: 32 per cycle.
- F. Data Link:
1. RS-485 Modbus RTU protocol, 4-wire connection.
 - a. Provide for firmware and software updates through the communications port.
- G. Meter Physical Characteristics:
1. Display: Backlit LCD with antiglare and scratch-resistant lens.
 2. Display of Metered Values: One screen to show at least four lines of user-selected values on one screen at the same time. Provide graphical representation of user-selected values. The screen selections available at the display shall include the following:
 - a. All meters, including those listed under the following:
 - 1) Measurements.
 - 2) THD.

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- 3) Energy.
 - 4) Demand.
 - 5) Minimum and maximum values.
 - 6) Power demand.
- H. Sampling Rate: Continuously sample and record voltage and current at a rate not less than 32 samples per cycle, simultaneously on all voltage and current channels of the meter.
- I. Meters:
1. Measurements: Instantaneous, in real time, rms to the 15th harmonic.
 - a. Voltage: L-L each phase, L-N each phase, and three-phase average.
 - b. Current: Each phase, three-phase average, and neutral.
 - c. Unbalanced current, L-L V ac and L-N V ac.
 - d. Active Power (+/- kW): Each phase and three-phase total.
 - e. Reactive Power (+/- kVAR): Each phase and three-phase total.
 - f. Apparent Power (+/- kVA): Each phase and three-phase total.
 - g. Displacement Power Factor: Each phase and three-phase total.
 - h. Distortion Power Factor: Each phase and three-phase total.
 - i. Frequency.
 2. THD from measurements simultaneously from the same cycle, through 15th harmonic.
 - a. Voltage THD: L-L each phase, L-N each phase, and three-phase average.
 - b. Current THD: Each phase and three-phase average.
 - c. Total demand distortion.
 3. Energy: Accumulated, indicate whether in-flow or out-flow, net and absolute values. Store the values in instrument's nonvolatile memory.
 - a. Active kWh.
 - b. Reactive kVARh.
 - c. Apparent kVAh.
 4. Demand: Present, last, predicted, peak.
 - a. Three-phase average current.
 - b. Three-phase total active power (kW).
 - c. Reactive power (kVAR).
 - d. Apparent power (kVA).
 5. Minimum and Maximum Values:
 - a. L-L and L-N voltages.
 - b. Current in each phase.

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- c. Power factor.
 - d. Active power total.
 - e. Reactive power total.
 - f. Apparent power total.
 - g. THD L-L and L-N voltages.
 - h. THD current in each phase.
 - i. Frequency.
- J. Power Demand, User Selectable:
1. Thermal Demand: Sliding window updated every second for the present demand and at end of the interval for the last interval. Adjustable window that can be set in 1-minute intervals, from 1 to 60 minutes.
 2. Block Interval with Optional Subintervals: Adjustable for 1-minute intervals, from 1 to 60 minutes. User-defined parameters for the following block intervals:
 - a. Sliding block that calculates demand every second, with intervals less than 15 minutes, and every 15 seconds with an interval between 15 and 60 minutes.
 - b. Fixed block that calculates demand at end of the interval.
 - c. Rolling block subinterval that calculates demand at end of each subinterval and displays it at end of the interval.
 3. Demand Calculation Initiated by a Synchronization Signal:
 - a. Signal is a pulse from an external source. Demand period begins with every pulse. Calculation shall be configurable as either a block or rolling block calculation.
 - b. Signal is a communication signal. Calculation shall be configurable as either a block or rolling block calculation.
 - c. Provide for synchronizing the demand with the internal of this instrument.
- K. Data Recording: Store the listed values in instrument's nonvolatile memory, indicate which of the three phases relates to the value. Attach a date and time stamp to the peak values and the alarms.
1. Minimum and maximum of real-time rms measurement.
 2. Energy.
 3. Demand values.
 4. Alarms, store the last 40 events.
- L. Alarms: Transmit a digital output and show on display when alarmed. Provide for no fewer than 15 metered items. Each alarm shall be user configured, by using the following options:
1. Date and time stamp.
 2. Enable-disable (default) or enable.
 3. Pickup magnitude.
 4. Pickup time delay.

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5. Dropout magnitude.
 6. Dropout time delay.
 7. Alarm type.
 8. Alarm label.
- M. Output Signals: Provide two mechanical relays, rated not less than 250-V ac, 2-A resistive, and rated for 200-k cycles or more. The relays shall be user configurable in one of the following listed modes:
1. Normal contact closure where the contacts change state for as long as the signal exists.
 2. Latched mode when the contacts change state when a pickup signal is received and are held until a dropout signal is received.
 3. Timed mode when the contacts change state when a pickup signal is received and are held for a preprogrammed duration.
- N. Meter Face:
1. Display: Backlit LCD display, six lines, with antiglare and scratch-resistant lens.
 2. Display of Metered Values: One screen to show at least four user-selected values on one screen at the same time.
 3. Provide for the reset of metered peak values.
- O. Capacities and Characteristics:
1. Power Supply: 120-V ac, 60 Hz.
 2. Circuit Connections:
 - a. Voltage: Measurements autoranging, 60- to 400-V ac L-N. Connect directly to low-voltage (600 V and less) without using voltage transformers. Meter impedance shall be 2-megohm L-L or greater. Overload Tolerance: 1500-V ac, rms, continuously.
 - b. Current: Connect to instrument grade current transformer with a metering range of 5 mA to 6 A. Overcurrent tolerance of the instrument shall be 10 A continuous, 50 A for 10 seconds once per hour, and 120 A for one second per hour.
 - c. Frequency: 45 to 65 Hz.
 - d. Time: Input from a GPS receiver to synchronize the internal clock of the instrument and to time-synchronize this instrument with the network to a deviation of not greater than 1 ms.

2.4 MONITORING OF POWER DISTRIBUTION EQUIPMENT

- A. Power Distribution Equipment: Web-enabled, direct connected to the LAN or intranet.
- B. Instrument Transformers: Comply with IEEE C57.13.
1. Potential Transformers: Secondary voltage rating of 120 V and NEMA C12.11 accuracy class of 0.3 with burdens of W, X, and Y.

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2. Current Transformers: Burden and accuracy class suitable for connected relays, meters, and instruments.
- C. Ethernet Connectivity:
1. A multipoint, RS-485 Modbus serial communications network shall be included within the equipment to interconnect breaker trip units, protective relays, drives, and metering devices equipped with communications.
 2. Serial communications network shall be wired to an Ethernet server in the incoming section of the equipment. Hardware and cabling required for the connection to the network shall be included within the power distribution equipment.
 3. Serial communications devices within the equipment shall be factory addressed and tested to verify reliable communications to the equipment's Ethernet Server.
- D. Ethernet Gateways:
1. User configurable; complying with UL 60950-1, and IEEE 802.3, Class 3 PoE.
 2. Include provisions to set initial Ethernet parameters via a local operator interface, or standard (RJ-45) Ethernet port, that is accessible from the front of the equipment. Initial setup shall be limited to basic Ethernet addressing parameters, as assigned by Owner.
 3. Common Gateway Features:
 - a. User configurable, with secure password-protected login process.
 - b. Include communications diagnostic information for serial and Ethernet ports as well as internal health status and memory management information through embedded HTML web pages for viewing using a standard web browser.
 - c. Include embedded HTML pages providing real-time information from devices connected to the Ethernet gateway's RS-485 port(s) through a standard web browser.
 - d. Allow firmware upgrades through the communications port.
 4. Include a "Quick-Start" guide with the equipment to describe the commissioning process for setting the equipment's Ethernet network address and for ensuring trouble-free data access from any PC on the network, using a standard web browser.
 5. Implement a common user interface ("look and feel") across all styles of power equipment.
- E. Distribution Equipment Monitoring:
1. Main menu and summary pages, factory configured, to display data for each communicating device within the power equipment lineup.
 2. Display Data:
 - a. Circuit summary page to display circuit name, three-phase average rms current, real power (kW), power factor, and breaker status (if applicable).
 - b. Load current summary page to display circuit name, and phase a, b, and c rms current values.
 - c. Demand current summary page to display circuit name, and phase a, b, and c average demand current values.

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- d. Power summary page to display circuit name, present demand power (kW), peak demand power (kW), and recorded time and date.
- e. Energy summary page to display circuit name, real energy (kWh), reactive energy (kVARh), and time/date of last reset.
- f. For unit substations equipped with dry-type transformer(s) and microbased temperature controller(s), the circuit summary web page listed above shall be augmented with transformer coil temperatures, phase a, b and c current values, and cooling fan status (on/off).

2.5 RACEWAYS AND BOXES

- A. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for electrical power wiring and NFPA 70 Class 1 remote-control and signaling circuits.
- B. Comply with requirements in Section 270528 "Pathways for Communications Systems" for control wiring, RS-232 cable, and NFPA 70 Class 2 remote-control and signaling circuits.

2.6 WIRES AND CABLES

- A. Electrical Power Wiring: Comply with manufacturer requirements.
 - 1. Copper conductors are Type THHN/THWN-2.
 - 2. Balanced Twisted Pair Cable: 100-ohm, four-pair Category 6.
 - 3. RS-485 Cable: Paired, two pairs, twisted, No. 22 AWG, stranded (7x30) tinned-copper conductors.
 - 4. Low-Voltage Control Cable: Multiple conductor, color-coded, No. 20 AWG copper, minimum.
 - a. Sheath: PVC; except in plenum-type spaces, use sheath listed for plenums.
 - b. Ordinary Switching Circuits: Three conductors unless otherwise indicated.
 - c. Switching Circuits with Pilot Lights or Locator Feature: Five conductors unless otherwise indicated.
- B. RS-232 Cable:
 - 1. PVC-Jacketed, RS-232 Cable: Paired, two pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, polypropylene insulation, and individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage; PVC jacket. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
 - a. Type CM.
 - b. Flame Resistance: UL 1581, vertical tray.
 - 2. Plenum-Type, RS-232 Cable: Paired, two pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, plastic insulation, and individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage; plastic jacket. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.

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- a. Type CMP.
- b. Flame Resistance: NFPA 262, flame test.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Examine pathway elements intended for cables. Check raceways, cable trays, and other elements for compliance with space allocations, installation tolerances, hazards to cable installation, and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 POWER MONITORING SYSTEM INSTALLATION

- A. Comply with NECA 1.
- B. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters. Conceal raceway and cables except in unfinished spaces.
- C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.
- D. Wiring and Cabling Installation:
 - 1. Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for electrical power wiring.
- E. Raceways Installation:
 - 1. Comply with Section 260533 "Raceways and Boxes for Electrical Systems" for electrical power wiring and NFPA 70 Class 1 remote-control and signaling circuits.
- F. Identification Installation:
 - 1. Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for electrical power wiring.

3.3 GROUNDING

- A. For data communication wiring, comply with NECA/BICSI 568.
- B. For low-voltage control wiring and cabling, comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.4 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. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - 2. Test balanced twisted pair cabling for direct-current loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination, but not after cross-connection.
 - a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.2. Perform tests with a tester that complies with performance requirements in its "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in its "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
 - b. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide, or transfer the data from the instrument to the computer, save as text files, print, and submit.
 - 3. Power Monitoring System Tests.
 - a. Test Analog Signals:
 - 1) Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
 - 2) Check analog current signals using a precision current meter at zero, 50, and 100 percent.
 - 3) Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.
 - b. Test Digital Signals:
 - 1) Check digital signals using a jumper wire.
 - 2) Check digital signals using an ohmmeter to test for contact making or breaking.
 - c. I/O Control Loop Tests:
 - 1) Test every I/O point to verify that safety and operating control set points are as indicated and as required to operate controlled system safely and at optimum performance.
 - 2) Test every I/O point throughout its full operating range.
 - 3) Test every control loop to verify that operation is stable and accurate.
 - 4) Adjust control loop proportional, integral, and derivative settings to achieve optimum performance while complying with performance requirements indicated. Document testing of each control loop's precision and stability via trend logs.

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- 5) Test and adjust every control loop for proper operation according to sequence of operation.
 - 6) Test software and hardware interlocks for proper operation.
 - 7) Operate each analog point at the following:
 - a) Upper quarter of range.
 - b) Lower quarter of range.
 - c) At midpoint of range.
 - 8) Exercise each binary point.
 - 9) For every I/O point in the system, read and record each value at workstation, at controller, and at field instrument simultaneously. Value displayed at workstation and at field instrument shall match.
 - 10) Prepare and submit a report documenting results for each I/O point in the system, and include in each I/O point a description of corrective measures and adjustments made to achieve desired results.
- C. Wiring and cabling will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

3.5 FINAL REVIEW

- A. Submit written request to Architect when the power monitoring system is ready for final review. Written request shall state the following:
1. The system has been thoroughly inspected for compliance with Contract Documents and found to be in full compliance.
 2. The system has been calibrated, adjusted, and tested and found to comply with requirements of operational stability, accuracy, speed, and other performance requirements indicated.
 3. The system monitoring of electrical distribution systems results in operation according to sequences of operation indicated.
 4. The system is complete and ready for final review.
- B. Review by Architect will be made after receipt of written request. A field report shall be issued to document observations and deficiencies.
- C. Take prompt action to remedy deficiencies indicated in field report and submit a second written request when all deficiencies have been corrected. Repeat process until no deficiencies are reported.
- D. Final review shall include a demonstration to parties participating in final review.

3.6 MAINTENANCE SERVICE

- A. Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by manufacturer's authorized service representative. Include semiannual preventive maintenance, repair or replacement of defective components, cleaning, and adjusting as required for proper system operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

3.7 SOFTWARE AND INTEGRATION

- A. Required software license(s) shall be provided for meter data integration into the FMS.
- B. Provide full integration support to the FMS contractor as required. Complete system integration is the responsibility of both the meter system provider and the FMS contractor.

3.8 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain the meters.
- B. Extent of Training:
 - 1. Base extent of training on scope and complexity of power monitoring system indicated and training requirements indicated. Provide extent of training required to satisfy requirements indicated even if more than minimum training requirements are indicated.
 - 2. Inform Owner of anticipated training requirements if more than minimum training requirements are indicated.
 - 3. Minimum Training Requirements:
 - a. Provide no fewer than three days of training total.
 - b. Stagger training over multiple training classes to accommodate Owner's requirements. All training shall occur before end of warranty period.
- C. Attendee Training Manuals:
 - 1. Provide each attendee with a color hard copy of all training materials and visual presentations.
 - 2. Hard-copy materials shall be organized in a three-ring binder with table of contents and individual divider tabs marked for each logical grouping of subject matter. Organize material to provide space for attendees to take handwritten notes within training manuals.
 - 3. In addition to hard-copy materials included in training manual, provide each binder with a sleeve or pocket that includes a DVD or flash drive with PDF copy of all hard-copy materials.
- D. Instructor Requirements:
 - 1. One or multiple qualified instructors, as required, to provide training.

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2. Instructors shall have no fewer than five years of providing instructional training on no fewer than five past projects with similar electrical monitoring system scope and complexity.
- E. Training Outline: Submit training outline for Owner review at least 10 business days before scheduling training. Outline shall include a detailed agenda for each training day that is broken down into each training session that day, training objectives for each training session, and synopses for each lesson planned.
- F. On-Site Training: Train eight (8) individuals.
1. Owner will provide conditioned classroom or workspace with ample desks or tables, chairs, power, and data connectivity for instructor and each attendee.
 2. Instructor shall provide training materials, projector, and other audiovisual equipment used in training.
 3. Provide as much of training located on-site as deemed feasible and practical by Owner.
 4. On-site training shall include regular walk-through tours, as required, to observe each unique product type installed with hands-on review of operation, calibration, and service requirements.
 5. The workstation provided with the system shall be used in training. If workstation is not indicated, provide a temporary workstation to convey training content.
- G. At Completion of Training:
1. Staff familiar with the system installed are capable of demonstrating operation of the system during final review.
 2. Demonstration shall include, but not be limited to, the following:
 - a. Subparagraphs below are examples only and must be revised to suit Project.
 - b. Accuracy and calibration of 10 I/O points randomly selected by reviewers. If review finds that some I/O points are not properly calibrated and not satisfying performance requirements indicated, additional I/O points may be selected by reviewers until total I/O points being reviewed that satisfy requirements equals quantity indicated.
 - c. Reporting of alarm conditions for randomly selected alarms, including different classes of alarms, to ensure that alarms are properly received by operators and workstations.
 - d. Trends, summaries, logs, and reports set-up for Project.
 - e. Software's ability to communicate with controllers, workstations, and uploading and downloading of control programs.
 - f. Data entry to show Project-specific customizing capability including parameter changes.
 - g. Step through penetration tree, display all graphics, demonstrate dynamic update, and direct access to graphics.
 - h. Execution of digital and analog commands in graphic mode.
 - i. Spreadsheet and curve plot software and its integration with database.

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- j. Online user guide and help functions.
3. For Each Meter:
- a. Memory: Programmed data, parameters, trend, and alarm history collected during normal operation is not lost during power failure.
 - b. Operator Interface: Ability to connect directly to each meter with a portable workstation.
 - c. Wiring Labels: Match control drawings.
 - d. Network Communication: Ability to locate a meter on the network. Communication architecture matches Shop Drawings.
 - e. Nameplates and Tags: Accurate and permanently attached to control panel doors, instrument, actuators, and devices.
4. For Each Workstation:
- a. I/O point lists agree with naming conventions.
 - b. Graphics are complete.
 - c. UPS unit, if applicable, operates.

END OF SECTION

SECTION 26 0923 - LIGHTING CONTROL DEVICES

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. 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.

PART 2 PRODUCTS

2.1 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.

2.2 INDOOR OCCUPANCY AND 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.

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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.

2.3 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.

2.4 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."

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- 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."

PART 3 EXECUTION

3.1 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.

3.2 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.

3.3 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.

3.4 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.

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- E. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.5 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.

3.6 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.

3.7 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.

3.8 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.

3.9 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

SECTION 26 0943.23 - RELAY-BASED LIGHTING CONTROLS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes: Lighting control panels using mechanically held relays for switching.
- B. Section Includes: Networked lighting control panels using control-voltage relays for switching and that are interoperable with FMS system.

1.3 DEFINITIONS

- A. BAS: Building automation system.
- B. BACNET: Direct digital control.
- C. IP: Internet protocol.
- D. Monitoring: Acquisition, processing, communication, and display of equipment status data, metered electrical parameter values, power quality evaluation data, event and alarm signals, tabulated reports, and event logs.

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 control modules, power distribution components, relays, manual switches and plates, and conductors and cables.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
 - 3. Sound data including results of operational tests of central dimming controls.
 - 4. Operational documentation for software and firmware.
- B. Shop Drawings: For each relay panel and related equipment.
 - 1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
 - 2. Detail enclosure types and details for types other than NEMA 250, Type 1.

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3. Detail wiring partition configuration, current, and voltage ratings.
4. Short-circuit current rating of relays.
5. Address Drawing: Reflected ceiling plan and floor plans, showing connected luminaires, address for each luminaire, and luminaire groups. Base plans on construction plans, using the same legend, symbols, and schedules.
6. Point List and Data Bus Load: Summary list of all control devices, sensors, ballasts, and other loads. Include percentage of rated connected load and device addresses.
7. Wire Termination Diagrams and Schedules: Coordinate nomenclature and presentation with Drawings and block diagram. Differentiate between manufacturer-installed and field-installed wiring.
8. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices to be used. Describe characteristics of network and other data communication lines.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Submit evidence that lighting controls are compatible with connected monitoring and specified in Section 230923 "Direct Digital Control (BACNET) System for HVAC."
 1. Show interconnecting signal and control wiring, and interface devices that prove compatibility of inputs and outputs.
 2. For networked controls, list network protocols and provide statements from manufacturers that input and output devices comply with interoperability requirements of the network protocol.
- B. Qualification Data: For testing agency.
- C. Field quality-control reports.
- D. Software licenses and upgrades required by and installed for operation and programming of digital and analog devices.
- E. Sample Warranty: For manufacturer's special warranty.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For lighting controls to include in emergency, operation, and maintenance manuals.
- B. Software and Firmware Operational Documentation:
 1. Software operating and upgrade manuals.
 2. Program Software Backup: Username and password for manufacturer's support website.

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3. Device address list.
4. Printout of software application and graphic screens.
5. Testing and adjusting of panic and emergency power features.

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. Lighting Control Relays: Equal to 10 percent of amount installed for each size indicated, but no fewer than 8.

1.8 QUALITY ASSURANCE

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

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Handle and prepare panels for installation according to NECA 407.

1.10 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of standalone multipreset modular dimming controls that fail in materials or workmanship within specified warranty period.
 1. Failures include, but are not limited to, the following:
 - a. Damage from transient voltage surges.
 2. Warranty Period: Cost to repair or replace any parts for two years from date of Substantial Completion.
 3. Extended Warranty Period: Cost of replacement parts (materials only, f.o.b. the nearest shipping point to Project site), for eight years, that failed in service due to transient voltage surges.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Sequence of Operations: Input signal from field-mounted manual switches, or digital signal sources, shall open or close one or more lighting control relays in the lighting control panels. Any combination of inputs shall be programmable to any number of control relays.
 1. Integration with facility management System (FMS):

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2. Communication Interface: Shall be BACnet compliant. The communication interface shall enable the FMS system operator to remotely control and monitor lighting from the Netflix Tridium Niagara Facility Management System (FMS) operator workstation. Control features and monitoring points displayed locally at lighting panel shall be available through the FMS system. Comply with requirements in Section 230900 "Facility Management System."
- B. Surge Protective Device: Factory installed as an integral part of control components or field-mounted surge suppressors complying with UL 1449, SPD Type 2.
- 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 47 CFR 15, Subparts A and B, for Class A digital devices.
- E. Comply with UL 916.

2.2 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Lighting control panels 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."
 2. Component Importance Factor: 1.5

2.3 LIGHTING CONTROL RELAY PANELS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Douglas Lighting Controls
 2. WattStopper; a Legrand® Group brand.
 3. Crestron
- B. Description: Standalone lighting control panel using mechanically latched relays to control lighting and appliances.
- C. Lighting Control Panel:
 1. A single enclosure with incoming lighting branch circuits, control circuits, switching relays, and on-board timing and control unit.
 2. A vertical barrier separating branch circuits from control wiring.
- D. Control Unit: Contain the power supply and electronic control for operating and monitoring individual relays.
 1. Timing Unit:

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- a. 365-day calendar, astronomical clock, and automatic adjustments for daylight savings and leap year.
 - b. Clock configurable for 12-hour (A.M./P.M.) or 24-hour format.
 - c. Four independent schedules, each having 24 time periods.
 - d. Schedule periods settable to the minute.
 - e. Day-of-week, day-of-month, day-of-year with one-time or repeating capability.
 - f. 10 special date periods.
2. Sequencing Control with Override:
- a. Automatic sequenced on and off switching of selected relays at times set at the timing unit, allowing timed overrides from external switches.
 - b. Sequencing control shall operate relays one at a time, completing the operation of all connected relays in not more than 10 seconds.
 - c. Override control shall allow any relay connected to it to be switched on or off by a field-deployed manual switch or by an automatic switch, such as an occupancy sensor.
 - d. Override control "blink warning" shall warn occupants approximately five minutes before actuating the off sequence.
3. Nonvolatile memory shall retain all setup configurations. After a power failure, the controller shall automatically reboot and return to normal system operation, including accurate time of day and date.
- E. Relays: Electrically operated, mechanically held single-pole switch, rated at 20 A at 277 V. Short-circuit current rating shall be not less than 5 kA. Control shall be three-wire, 24-V ac.
- F. Relays: Electrically operated, mechanically held single-pole switch, rated at 20 A at 120-V tungsten, 30 A at 277-V ballast, 1.5 hp at 120 V, and 3 hp at 277 V. Short-circuit current rating shall be not less than 14 kA. Control shall be three-wire, 24-V ac.
- G. Power Supply: NFPA 70, Class 2, sized for connected equipment, plus 20 percent spare capacity. Powered from a dedicated branch circuit of the panelboard that supplies power to the line side of the relays, sized to provide control power for the local panel-mounted relays, bus system, low-voltage inputs, field-installed occupancy sensors, and photo sensors.
- H. Operator Interface:
1. Integral alphanumeric keypad and digital display, and intuitive drop-down menus to assist in programming.
 2. Log and display relay on-time.
 3. Connect relays to one or more time and sequencing schemes.

2.4 NETWORKED LIGHTING CONTROL PANELS

- A. Description: Lighting control panels using mechanically latched relays to control lighting and appliances. The panels shall be capable of being interconnected with digital communications to appear to the operator as a single lighting control system.
- B. Lighting Control Panels:
 - 1. A single enclosure with incoming lighting branch circuits, control circuits, switching relays, and on-board timing and control unit.
 - 2. A vertical barrier separating branch circuits from control wiring.
- C. Main Control Unit: Installed in the main lighting control panel only; powered from the branch circuit of the standard control unit.
 - 1. Ethernet Communications: Comply with TCP/IP protocol. The main control unit shall provide for programming of all control functions of the main and all networked slave lighting control panels including timing, sequencing, and overriding.
 - 2. Compliance with BACNET: Controllers shall support serial MS/TP and Ethernet IP communications, and shall be able to communicate directly via FMS system for HVAC RS-485 serial networks and Ethernet 10Base-T networks as a native device.
 - 3. Web Server: Display information listed below over a standard Web-enabled server for displaying information over a standard browser.
 - a. A secure, password-protected login screen for modifying operational parameters, accessible to authorized users via Web page interface.
 - b. Panel summary showing the master and slave panels connected to the controller.
 - c. Controller diagnostic information.
 - d. Show front panel mimic screens for setting up controller parameters, input types, zones, and operating schedules. These mimic screens shall also allow direct breaker control and zone overrides.
 - 4. Timing Unit:
 - a. 365-day calendar, astronomical clock, and automatic adjustments for daylight savings and leap year.
 - b. Clock configurable for 12-hour (A.M./P.M.) or 24-hour format.
 - c. Four independent schedules, each having 24 time periods.
 - d. Schedule periods settable to the minute.
 - e. Day-of-week, day-of-month, day-of-year with one-time or repeating capability.
 - f. 16 special date periods.
 - 5. Time Synchronization: The timing unit shall be updated not less than every hour(s) with the network time server.
 - 6. Sequencing Control with Override:

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- a. Automatic sequenced on and off switching of selected relays at times set at the timing unit, allowing timed overrides from external switches.
 - b. Sequencing control shall operate relays one at a time, completing the operation of all connected relays in not more than 10 seconds.
 - c. Override control shall allow any relay connected to it to be switched on or off by a field-deployed manual switch or by an automatic switch, such as an occupancy sensor.
 - d. Override control "blinking warning" shall warn occupants approximately five minutes before actuating the off sequence.
 - e. Activity log, storing previous relay operation, including the time and cause of the change of status.
 - f. Download firmware to the latest version offered by manufacturer.
- D. Standard Control Unit, Installed in All Lighting Control Panels: Contain electronic controls for programming the operation of the relays in the control panel, contain the status of relays, and contain communications link to enable the digital functions of the main control unit. Comply with UL 916.
1. Electronic control for operating and monitoring individual relays, and display relay on-time.
 2. Nonvolatile memory shall retain all setup configurations. After a power failure, the controller shall automatically reboot and return to normal system operation.
 3. Integral keypad and digital-display front panel for local setup, including the following:
 - a. Blink notice, time adjustable from software.
 - b. Ability to log and display relay on-time.
 - c. Capability for accepting downloadable firmware so that the latest production features may be added in the future without replacing the module.
- E. Relays: Electrically operated, mechanically held single-pole switch, rated at 20 A at 120-V tungsten, 30 A at 277-V ballast, 1.5 hp at 120 V, and 3 hp at 277 V. Short-circuit current rating shall be not less than 14 kA. Control shall be three-wire, 24-V ac.
- F. Power Supply: NFPA 70, Class 2, UL listed, sized for connected equipment, plus not less than 20 percent spare capacity. Powered from a dedicated branch circuit of the panelboard that supplies power to the line side of the relays, sized to provide control power for the local panel-mounted relays, bus system, low-voltage inputs, field-installed occupancy sensors, and low-voltage photo sensors.
- G. Operator Interface: At the main control unit, provide interface for a tethered connection of a portable PC running MS Windows for configuring all networked lighting control panels using setup software designed for the specified operating system. Include one portable device for initial programming of the system and training of Owner's personnel. That device shall remain the property of Owner.
- H. Software:
1. Menu-driven data entry.

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2. Online and offline programming and editing.
3. Provide for entry of the room or space designation for the load side of each relay.
4. Monitor and control all relays, showing actual relay state and the name of the automatic actuating control, if any.
5. Size the software appropriate to the system.

2.5 MANUAL SWITCHES AND PLATES

- A. Push-Button Switches: Modular, momentary contact, three wire, for operating one or more relays and to override automatic controls.
 1. Match color and style specified in Section 262726 "Wiring Devices."
 2. Integral green LED pilot light to indicate when circuit is on.
 3. Internal white LED locator light to illuminate when circuit is off.
- B. Wall Plates: Single and multigang plates as specified in Section 262726 "Wiring Devices."
- C. Legend: Engraved or permanently silk-screened on wall plate where indicated. Use designations indicated on Drawings.

2.6 FIELD-MOUNTED SIGNAL SOURCES

- A. Daylight Harvesting Switching Controls: Comply with Section 260923 "Lighting Control Devices." Control power may be taken from the lighting control panel, and signal shall be compatible with the relays.
- B. Indoor Occupancy Sensors: Comply with Section 260923 "Lighting Control Devices." Control power may be taken from the lighting control panel, and signal shall be compatible with the relays.

2.7 CONDUCTORS AND CABLES

- A. Power Wiring to Supply Side of Class 2 Power Source: Not smaller than No. 12 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Class 1 Control Cables: Multiconductor cable type required by manufacturer with copper conductors not smaller than No. 16 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Twisted-Pair Data Cable: Comply with requirements in Section 271513 "Communications Copper Horizontal Cabling."

PART 3 EXECUTION

3.1 EXAMINATION

- A. Receive, inspect, handle, and store panels according to NECA 407.
- B. Examine panels before installation. Reject panels that are damaged or rusted or have been subjected to water saturation.
- C. Examine elements and surfaces to receive panels for compliance with installation tolerances and other conditions affecting performance of the Work.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 WIRING INSTALLATION

- A. Comply with NECA 1.
- B. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Conceal raceway and cables except in unfinished spaces.
 - 1. Install plenum cable in environmental airspaces, including plenum ceilings.
 - 2. Comply with requirements for cable trays specified in Section 260536 "Cable Trays for Electrical Systems."
 - 3. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."
- C. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
- D. 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.

3.3 PANEL INSTALLATION

- A. Comply with NECA 1.
- B. Install panels and accessories according to NECA 407.
- C. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."
- D. Mount top of trim 90 inches (2286 mm) above finished floor unless otherwise indicated.

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- E. Mount panel cabinet plumb and rigid without distortion of box.
- F. Install filler plates in unused spaces.

3.4 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- B. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Section 260553 "Identification for Electrical Systems."
- C. Create a directory to indicate loads served by each relay; incorporate Owner's final room designations. Obtain approval before installing. Use a PC or typewriter to create directory; handwritten directories are unacceptable.
- D. Lighting Control Panel Nameplates: Label each panel with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.5 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 tests and inspections with the assistance of a factory-authorized service representative.
- C. Tests and Inspections:
 - 1. Test Lighting Control system for proper operation, including all on/off programmable and manual controls for all interior and exterior controlled lighting. Prepare and submit report indicating tests and checks accomplished, and indicating system is fully functional.
 - 2. Perform each visual and mechanical inspection and electrical test for low-voltage air circuit breakers described below and low-voltage surge arrestors. Certify compliance with manufacturer's test parameters.
 - a. Circuit-Breaker Tests:
 - 1) Compare nameplate with Drawings and Specifications.
 - 2) Inspect physical and mechanical conditions.
 - 3) Inspect anchorage and alignment.
 - 4) Verify that the units are clean.
 - 5) Operate the circuit breaker to ensure smooth operation.
 - 6) Inspect bolted electrical connections for high resistance using one or more of the following methods:
 - a) A low-resistance ohmmeter.

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- b) Verify tightness of bolted electrical connections by calibrated torque wrench.
 - c) Thermographic survey.
 - 7) Inspect operating mechanism, contacts, and arc chutes in unsealed units.
 - 8) Perform adjustments for final protective device settings according to the overcurrent protective device coordination study. Comply with requirements in Section 260573 "Overcurrent Protective Device Coordination Study."
 - 9) Perform insulation resistance tests for one minute on each pole, phase-to-phase, and phase-to-ground with the circuit breaker closed and across each pole using manufacturer's published data.
 - 10) Perform a contact/pole-resistance test.
 - 11) Perform insulation-resistance tests on 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 for one minute. Follow manufacturer's written instructions for solid-state units.
 - 12) Determine long-time pickup and delay by primary current injection.
 - 13) Determine short-time pickup and delay by primary current injection.
 - 14) Determine ground-fault pickup and time delay by primary current injection.
 - 15) Determine instantaneous pickup by primary current injection.
 - 16) Test functions of the trip unit by means of secondary injection.
 - 17) Perform minimum pickup voltage tests on shunt trip and close coils according to manufacturer's published data.
 - 18) 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 trip logs and indicators.
 - 19) Verify operation of charging mechanism.
- b. Surge Arrestor Tests:
- 1) Compare nameplate with the Contract Documents.
 - 2) Inspect physical and mechanical conditions.
 - 3) Inspect anchorage, alignment, grounding, and clearances.
 - 4) Verify that the units are clean.
 - 5) Inspect bolted electrical connections for high resistance using one or more of the following methods:
 - a) Low-resistance ohmmeter.
 - b) Verify tightness of bolted electrical connections by calibrated torque wrench.
 - 6) Verify that the ground lead on each device is individually attached to a ground bus or ground electrode.

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- 7) Perform an insulation-resistance test on each arrester, phase terminal-to-ground using voltage according to manufacturer written instructions.
 - 8) Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems" for grounding tests.
3. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
- D. Lighting control panel will be considered defective if it does not pass tests and inspections.
 - E. Prepare test and inspection reports, including a certified report that identifies lighting control panels and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.6 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
 1. Complete installation and startup checks according to manufacturer's written instructions.
 2. Confirm correct communications wiring, initiate communications between panels, and program the lighting control system according to approved configuration schedules, time-of-day schedules, and input override assignments.
 3. Provide full integration support to the FMS contractor as required. Complete system integration is the responsibility of both the lighting system provider and the FMS contractor.

3.7 ADJUSTING

- A. Occupancy Adjustments: 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.

3.8 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.

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3.9 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain the control unit and operator interface.

END OF SECTION

SECTION 26 2213 - LOW-VOLTAGE DISTRIBUTION TRANSFORMERS

PART 1 GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Distribution, dry-type transformers with nominal primary and secondary rating of 600 V and less, with capacities up to 1500 kVA.
- 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 260548/15 "Seismic Controls for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.

1.2 ACTION SUBMITTALS

- A. Product Data:
 - 1. For each type of product.
- B. Shop Drawings:
 - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of field connections.
 - 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.
- C. Field Quality-Control Submittals:
 - 1. Field quality-control reports.

1.3 INFORMATIONAL SUBMITTALS

- A. Manufacturers' Published Instructions: Record copy of official installation and testing instructions issued to Installer by manufacturer for the following:
 - 1. Transformer working clearances, anchoring, torque values, and insulation-resistance testing.
- B. Source quality-control reports.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. ABB, Electrification Business.
 - 2. Eaton.
 - 3. Siemens Industry, Inc., Energy Management Division.
 - 4. Square D; Schneider Electric USA.

2.2 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 in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
- C. Transformers Rated 15 kVA and Larger:
 - 1. Comply with 10 CFR 431 (DOE 2016) efficiency levels.
 - 2. Marked as compliant with DOE 2016 efficiency levels by qualified electrical testing laboratory recognized by authorities having jurisdiction.

2.3 DISTRIBUTION TRANSFORMERS

- A. Comply with NFPA 70, and list and label as complying with UL 1561.
- B. Cores: Electrical grade, non-aging silicon steel with high permeability and low hysteresis losses.
 - 1. One leg per phase.
- C. Coils: Continuous windings without splices except for taps.
 - 1. Coil Material: Copper.
 - 2. Internal Coil Connections: Brazed or pressure type.
 - 3. Terminal Connections: Welded.
- D. Enclosure: Ventilated.
 - 1. KVA Ratings: Based on convection cooling only and not relying on auxiliary fans.
 - 2. Wiring Compartment: Sized for conduit entry and wiring installation.
 - 3. Environmental Protection:
 - a. Indoor: UL 50E, Type 2.

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- b. Outdoor: UL 50E, Type 3R.
- E. Taps for Transformers 3 kVA and Smaller: One 5 percent tap above normal full capacity.
- F. Taps for Transformers 7.5 to 24 kVA: One 5 percent tap above and one 5 percent tap below normal full capacity.
- G. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity.
- H. Insulation Class, Smaller Than 30 kVA: 180 deg C, UL-component-recognized insulation system with maximum of 115 deg C rise above 40 deg C ambient temperature.
- I. Insulation Class, 30 kVA and Larger: 220 deg C, UL-component-recognized insulation system with maximum of 115 deg C rise above 40 deg C ambient temperature.
- J. Grounding: Provide ground-bar kit or ground bar installed on inside of transformer enclosure.

2.4 IDENTIFICATION

- A. Nameplates:
 - 1. Engraved, laminated-acrylic or melamine plastic signs for distribution transformers, mounted with corrosion-resistant screws. Nameplates and label products are specified in Section 260553 "Identification for Electrical Systems."

PART 3 EXECUTION

3.1 EXAMINATION

- A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for transformers.
- B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's published 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 must be 5 Ω at location of transformer.
- E. Environment: Enclosures must be rated for environment in which they are located. Covers for UL 50E, Type 4X enclosures may not cause accessibility problems.

3.2 INSTALLATION

- A. Construct concrete bases and anchor floor-mounted transformers in accordance with manufacturer's published instructions, seismic requirements 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.
- B. Secure transformer to concrete base in accordance with manufacturer's published instructions.
- C. Secure covers to enclosure and tighten bolts to manufacturer-recommended torques to reduce noise generation.
- D. Remove shipping bolts, blocking, and wedges.

3.3 CONNECTIONS

- A. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Tighten electrical connectors and terminals in accordance with 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 conduit and conductor terminations.
- E. Provide vibration isolation pads to eliminate sound and vibration transmission to building structure. Pads shall be neoprene, rated for transformer weight. Mason Industries type _____

3.4 FIELD QUALITY CONTROL

- A. Engage a Electrical Testing Agency per Section 260880 to perform the following tests and inspections.
- B. Tests and Inspections:
 - 1. Small (Up to 167 kVA Single-Phase or 500 kVA Three-Phase) Dry-Type Transformer Field Tests:
 - a. Visual and Mechanical Inspection.
 - 1) Inspect physical and mechanical condition.
 - 2) Inspect anchorage, alignment, and grounding.

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- 3) Verify that resilient mounts are free and that shipping brackets have been removed.
 - 4) Verify that unit is clean.
 - 5) Perform specific inspections and mechanical tests recommended by manufacturer.
 - 6) Verify that as-left tap connections are as specified.
 - 7) Verify presence of surge arresters and that their ratings are as specified.
- b. Electrical Tests:
- 1) Measure resistance at windings, taps, and bolted connections.
 - 2) Perform insulation-resistance tests winding-to-winding and windings-to-ground. Apply voltage in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index: value of index may not be less than 1.0.
 - 3) Perform turns-ratio tests at tap positions. Test results may not deviate by more than one-half percent from either adjacent coils or calculated ratio. If test fails, replace transformer.
 - 4) Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.
- C. Test Labeling: On completion of satisfactory testing of units, attach dated and signed "Satisfactory Test" label to tested components.
- D. Nonconforming Work:
1. Transformer will be considered defective if it does not pass tests and inspections.
 2. Remove and replace units that do not pass tests or inspections and retest as specified above.
- E. Assemble and submit test and inspection reports.

3.5 CLEANING

- A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION

SECTION 26 2413 - SWITCHBOARDS

PART 1 GENERAL

1.1 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.

1.2 ACTION SUBMITTALS

- A. Product Data: For each switchboard, overcurrent protective device, surge protection device, ground-fault protector, accessory, and component.
- 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. Detail utility company's metering provisions with indication of approval by utility company.
 6. Include evidence of NRTL listing for series rating of installed devices.
 7. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
 8. 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.
 9. Include schematic and wiring diagrams for power, signal, and control wiring.
- C. Delegated Design Submittal:
1. For arc-flash hazard analysis.

2. For arc-flash labels.

1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer and 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.

1.4 FIELD QUALITY-CONTROL REPORTS

1.5 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.6 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.

1.7 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 6600 feet.

1.8 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: two 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.

PART 2 PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Switchboards shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - 1. Basis for Certification: Indicaton calculation. Shake-table testing shall comply with ICC-ES AC156.
 - 2. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.2 SWITCHBOARDS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. ABB, Electrification Business.
 - 2. Eaton.
 - 3. Siemens Industry, Inc., Energy Management Division.
 - 4. Square D; Schneider Electric USA.
- 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. Comply with NEMA PB 2.
- E. Comply with NFPA 70.
- F. Comply with UL 891.

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- G. Front-Connected, Front-Accessible Switchboards:
 - 1. Main Devices: Panel mounted.
 - 2. Branch Devices: Panel mounted.
 - 3. Sections front and rear aligned.
- H. Nominal System Voltage: As indicated.
- I. Main-Bus Continuous: As indicated.
- J. 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."
- K. Indoor Enclosures: Steel, NEMA 250, Type 1.
- L. Outdoor Enclosures: Type 3R.
 - 1. Finish: Factory-applied finish in manufacturer's standard color; undersurfaces treated with corrosion-resistant undercoating.
 - 2. Enclosure: Flat roof; bolt-on rear covers for each section, with provisions for padlocking.
- M. Space Heaters: Factory-installed electric space heaters of sufficient wattage in each vertical section to maintain enclosure temperature above expected dew point.
 - 1. Space-Heater Control: Thermostats to maintain temperature of each section above expected dew point.
 - 2. Space-Heater Power Source: Transformer, factory installed in switchboard.
- N. 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.
- O. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.
- P. Removable, Hinged Rear Doors and Compartment Covers: Secured by captive thumb screws, for access to rear interior of switchboard.
- Q. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.
- R. Buses and Connections: Three phase, four wire unless otherwise indicated.

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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: Tin-plated, high-strength, electrical-grade aluminum alloy with tin-plated aluminum circuit-breaker line connections.
 3. Tin-plated aluminum feeder circuit-breaker line connections.
 4. Load Terminals: Insulated, rigidly braced, runback bus extensions, of same material as through buses, equipped with mechanical, compression connectors for outgoing circuit conductors. Provide load terminals for future circuit-breaker positions at full-ampere rating of circuit-breaker position.
 5. Ground Bus: Minimum-size required by UL 891, 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: 200 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.
- S. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

2.3 SURGE PROTECTION DEVICES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. ABB, Electrification Business.
 2. Advanced Protection Technologies Inc. (APT).
 3. Eaton.
 4. Siemens Industry, Inc., Energy Management Division.
 5. Square D; Schneider Electric USA.
- B. SPDs: Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1449, Type 1.
- C. Features and Accessories:
1. Integral disconnect switch.

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2. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
 3. Indicator light display for protection status.
 4. Form-C contacts rated at 2 A and 24-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
 5. Surge counter.
- D. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 250kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.
- 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 and 700 V for 208Y/120 V.
 2. Line to Ground: 1200 V for 480Y/277 V and 1200 V for 208Y/120 V.
 3. Line to Line: 2000 V for 480Y/277 V and 1000 V for 208Y/120 V.
- F. SCCR: Equal or exceed 200 kA.

2.4 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.
1. 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. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
 3. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).
 4. 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. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.

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- d. Communication Capability: Integral communication module with functions and features compatible with power monitoring and control system specified in Section 260913 "Electrical Power Monitoring and Control."
- e. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at [55] [75] percent of rated voltage.
- f. 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.
- g. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

2.5 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 or bushing type; single secondary winding and secondary shorting device. Burden and accuracy shall be consistent with connected metering and relay devices.
 - 3. Current Transformers for Neutral and Ground-Fault Current Sensing: Connect secondary wiring to ground overcurrent relays, via shorting terminals, to provide selective tripping of main and tie circuit breaker. Coordinate with feeder circuit-breaker, ground-fault protection.
- B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:
 - 1. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:
 - a. Phase Currents, Each Phase: Plus or minus 0.5 percent.
 - b. Phase-to-Phase Voltages, Three Phase: Plus or minus 0.5 percent.
 - c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 0.5 percent.
 - d. Megawatts: Plus or minus 1 percent.
 - e. Megavars: Plus or minus 1 percent.
 - f. Power Factor: Plus or minus 1 percent.
 - g. Frequency: Plus or minus 0.1 percent.
 - h. Accumulated Energy, Megawatt Hours: Plus or minus 1 percent; accumulated values unaffected by power outages up to 72 hours.
 - i. Megawatt Demand: Plus or minus 1 percent; demand interval programmable from five to 60 minutes.
 - j. Contact devices to operate remote impulse-totalizing demand meter.

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2. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.

2.6 CONTROL POWER

- A. Control Circuits: 120-V ac, supplied through secondary disconnecting devices from control-power transformer.
- B. Electrically Interlocked Main and Tie Circuit Breakers: Two control-power transformers in separate compartments, with interlocking relays, connected to the primary side of each control-power transformer at the line side of the associated main circuit breaker. 120-V secondaries connected through automatic transfer relays to ensure a fail-safe automatic transfer scheme.
- C. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.
- D. Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

2.7 ACCESSORY COMPONENTS AND FEATURES

- A. 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.
- B. Spare-Fuse Cabinet: Suitably identified, wall-mounted, lockable, compartmented steel box or cabinet. Arrange for wall mounting.
- C. 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.

2.8 IDENTIFICATION

- A. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Receive, inspect, handle, and store switchboards according to NEMA PB 2.
- B. Install switchboards and accessories according to NEMA PB 2.1.

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- C. 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.
- D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, straps and brackets, and temporary blocking of moving parts from switchboard units and components.
- E. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."
- F. 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.
- G. Install filler plates in unused spaces of panel-mounted sections.
- H. Install overcurrent protective devices, surge protection devices, and instrumentation.
 - 1. Set field-adjustable switches and circuit-breaker trip ranges.
- I. Install spare-fuse cabinet.
- J. Comply with NECA 1.
- K. Comply with requirements for terminating feeder bus specified in Section 262500 "Enclosed Bus Assemblies." Drawings indicate general arrangement of bus, fittings, and specialties.
- L. 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.

3.2 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."

3.3 FIELD QUALITY CONTROL

- A. Engage an Electrical Testing Agency per Section 260880 to 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. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Switchboard will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.4 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories.

END OF SECTION

SECTION 26 2416 - PANELBOARDS

PART 1 GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Distribution panelboards.
 - 2. Lighting and appliance branch-circuit panelboards.

1.2 DEFINITIONS

- A. MCCB: Molded-case circuit breaker.
- B. SPD: Surge protective device.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of panelboard.
- B. Shop Drawings: For each panelboard and related equipment.
 - 1. Include dimensioned plans, elevations, sections, and details.
 - 2. Detail enclosure types including mounting and anchorage, environmental protection, knockouts, corner treatments, covers and doors, gaskets, hinges, and locks.
 - 3. Detail bus configuration, current, and voltage ratings.
 - 4. Short-circuit current rating of panelboards and overcurrent protective devices.
 - 5. Include evidence of NRTL listing for series rating of installed devices.
 - 6. Include evidence of NRTL listing for SPD as installed in panelboard.
 - 7. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
 - 8. Include wiring diagrams for power, signal, and control wiring.
 - 9. Key interlock scheme drawing and sequence of operations.
 - 10. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards.

1.4 INFORMATIONAL SUBMITTALS

- A. Panelboard schedules for installation in panelboards.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.6 FIELD CONDITIONS

- A. Service Conditions: NEMA PB 1, usual service conditions, as follows:
 - 1. Ambient temperatures within limits specified.
 - 2. Altitude not exceeding 6600 feet.

1.7 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.

PART 2 PRODUCTS

2.1 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. 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 PB 1.
- D. Comply with NFPA 70.
- E. 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 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 (Mill and Production Support Services Buildings): NEMA 250, Type 5.
 - 2. Height: 84 inches maximum.
 - 3. 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.

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- F. Incoming Mains Location: As required.
- G. Phase, Neutral, and Ground Buses: Hard-drawn copper, 98 percent conductivity.
- H. Conductor Connectors: Suitable for use with conductor material and sizes.
 - 1. Material: Hard-drawn copper, 98 percent conductivity.
 - 2. Main and Neutral Lugs: Mechanical type, with a lug on the neutral bar for each pole in the panelboard.
 - 3. Ground Lugs and Bus-Configured Terminators: Mechanical type, with a lug on the bar for each pole in the panelboard.
 - 4. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
 - 5. Subfeed (Double) Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
- I. 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 shall have meter enclosures, wiring, connections, and other provisions for utility metering. Coordinate with utility company for exact requirements.
- J. Future Devices: Panelboards shall have mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.
- K. 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.

2.2 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
- B. Surge Suppression: Factory installed as an integral part of indicated panelboards, complying with UL 1449 SPD Type 1.

2.3 POWER PANELBOARDS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. ABB, Electrification Business.
 - 2. Eaton.
 - 3. ESL Power Systems, Inc.

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4. Siemens Industry, Inc., Energy Management Division.
 5. Square D; Schneider Electric USA.
- 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: Plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.
- F. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.
- G. Contactors in Main Bus: NEMA ICS 2, Class A, mechanically held, general-purpose controller, with same short-circuit interrupting rating as panelboard.
1. External Control-Power Source: 120-V branch circuit.

2.4 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. ABB, Electrification Business.
 2. Eaton.
 3. Siemens Industry, Inc., Energy Management Division.
 4. Square D; Schneider Electric USA.
- B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.
- C. Mains: As indicated.
- D. Branch Overcurrent Protective Devices: Plug-in circuit breakers, replaceable without disturbing adjacent units.
- E. Contactors in Main Bus: NEMA ICS 2, Class A, mechanically held, general-purpose controller, with same short-circuit interrupting rating as panelboard.
1. External Control-Power Source: 24-V control circuit.
- F. Doors: Concealed hinges (Door-in-Door); secured with flush latch with tumbler lock; keyed alike.

2.5 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. ABB, Electrification Business.
 2. Eaton.
 3. Siemens Industry, Inc., Energy Management Division.
 4. Square D; Schneider Electric USA.
- B. MCCB: Comply with UL 489, with interrupting capacity to meet available fault currents.
1. Thermal-Magnetic Circuit Breakers:
 - a. Inverse time-current element for low-level overloads.
 - b. Instantaneous magnetic trip element for short circuits.
 - c. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
 3. Electronic Trip Circuit Breakers:
 - a. RMS sensing.
 - b. Field-replaceable rating plug or electronic trip.
 - c. Digital display of settings, trip targets, and indicated metering displays.
 - d. Multi-button keypad to access programmable functions and monitored data.
 - e. Ten-event, trip-history log. Each trip event shall be recorded with type, phase, and magnitude of fault that caused the trip.
 - f. Integral test jack for connection to portable test set or laptop computer.
 - g. Field-Adjustable Settings:
 - 1) Instantaneous trip.
 - 2) Long- and short-time pickup levels.
 - 3) Long and short time adjustments.
 - 4) Ground-fault pickup level, time delay, and I squared T response.
 4. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).
 5. GFEP Circuit Breakers: Class B ground-fault protection (30-mA trip).
 6. Arc-Fault Circuit Interrupter Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration.
 7. Subfeed Circuit Breakers: Vertically mounted.
 8. MCCB Features and Accessories:

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- 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. Communication Capability: Integral communication module with functions and features compatible with power monitoring and control system specified in Section 260913 "Electrical Power Monitoring and Control."
 - h. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
 - i. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.
- C. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.
- 1. Fuses and Spare-Fuse Cabinet: Comply with requirements specified in Section 262813 "Fuses."

2.6 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.

2.7 ACCESSORY COMPONENTS AND FEATURES

PART 3 EXECUTION

3.1 INSTALLATION

- A. Comply with NECA 1.
- B. Install panelboards and accessories according to NEMA PB 1.1.

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- C. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."
- D. Mount top of trim 90 inches above finished floor unless otherwise indicated.
- E. Mount panelboard cabinet plumb and rigid without distortion of box.
- F. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.
- G. Install overcurrent protective devices and controllers not already factory installed.
 - 1. Set field-adjustable, circuit-breaker trip ranges.
- H. 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.
- I. Install filler plates in unused spaces.
- J. 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.
- K. Arrange conductors in gutters into groups and bundle and wrap with wire ties.

3.2 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; 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.

3.3 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Acceptance Testing Preparation:

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1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
 2. Test continuity of each circuit.
- C. Tests and Inspections:
1. Perform each visual and mechanical inspection and electrical test for low-voltage air circuit breakers stated in NETA ATS. 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.
- D. Panelboards will be considered defective if they do not pass tests and inspections.
- E. 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.

END OF SECTION

SECTION 26 2726 - WIRING DEVICES

PART 1 GENERAL

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.

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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.

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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.

PART 2 PRODUCTS

2.1 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:

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- 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.

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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.

2.2 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.

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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.

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- 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:

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- 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.

2.3 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.

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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.

2.4 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.

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- 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

2.5 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.

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- 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.

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- 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.

2.6 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:

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- 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.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Receptacles:
 1. Verify that receptacles to be procured and installed for Owner-furnished equipment are compatible with mating attachment plugs on equipment.

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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.

3.2 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.

3.3 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.

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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.

3.4 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.

3.5 INSTALLATION OF PIN-AND-SLEEVE RECEPTACLES

A. Comply with manufacturer's instructions.

B. Reference Standards:

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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.

3.6 INSTALLATION OF CORD REELS AND FITTINGS

- A. Comply with manufacturer's instructions.

3.7 INSTALLATION OF CONNECTORS, CORDS, AND PLUGS

- A. Comply with manufacturer's instructions.

3.8 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.

3.9 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.

3.10 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.

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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.

3.11 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.

3.12 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.

3.13 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.

3.14 SYSTEM STARTUP FOR SWITCHES

- A. Perform startup service.
 - 1. Complete installation and startup checks for momentary switches and dimmer switches in accordance with manufacturer's instructions.

3.15 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.

3.16 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

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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

SECTION 26 2813 - FUSES

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Cartridge fuses rated 600 V ac and less for use in the following:
 - a. Control circuits.
 - b. 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.

PART 2 PRODUCTS

2.1 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.

2.2 CARTRIDGE FUSES

- A. Characteristics: NEMA FU 1, current-limiting, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.
 - 1. Type RK-1: 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.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.
- B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.
- C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.
- D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FUSE APPLICATIONS

- A. Cartridge Fuses:
 - 1. 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.

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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.

3.3 INSTALLATION

- A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

3.4 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

SECTION 26 2816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Fusible switches.
 - 2. Nonfusible switches.
 - 3. Receptacle switches.
 - 4. Shunt trip switches.
 - 5. Molded-case circuit breakers (MCCBs).
 - 6. Molded-case switches.
 - 7. Enclosures.

1.3 DEFINITIONS

- A. NC: Normally closed.
- B. NO: Normally open.
- C. SPDT: Single pole, double throw.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include nameplate ratings, dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
 - 1. Enclosure types and details for types other than NEMA 250, Type 1.
 - 2. Current and voltage ratings.
 - 3. Short-circuit current ratings (interrupting and withstand, as appropriate).
 - 4. Include evidence of a nationally recognized testing laboratory (NRTL) listing for series rating of installed devices.

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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.

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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.

PART 2 PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Enclosed switches and circuit breakers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.2 GENERAL REQUIREMENTS

- A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single manufacturer.
- B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

- D. Comply with NFPA 70.

2.3 FUSIBLE SWITCHES

- A. 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.

2.4 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.

2.5 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.

2.6 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.

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- 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.

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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.

2.7 ENCLOSURES

- A. Enclosed Switches and Circuit Breakers: UL 489, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.
- B. Enclosure Finish: The enclosure shall be finished with gray baked enamel paint, electrodeposited on cleaned, phosphatized steel (NEMA 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.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.
 1. Commencement of work shall indicate Installer's acceptance of the areas and conditions as satisfactory.

3.2 ENCLOSURE ENVIRONMENTAL RATING APPLICATIONS

- A. Enclosed Switches and Circuit Breakers: Provide enclosures at installed locations with the following environmental ratings.

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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.

3.3 INSTALLATION

- A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.
- C. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."
- D. Temporary Lifting Provisions: Remove temporary lifting of eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- E. Install fuses in fusible devices.
- F. Comply with NFPA 70 and NECA 1.

3.4 IDENTIFICATION

- A. Comply with requirements in Section 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.

3.5 FIELD QUALITY CONTROL

- A. Perform tests and inspections with the assistance of a factory-authorized service representative.
- B. Tests and Inspections for Switches:
 1. Visual and Mechanical Inspection:
 - a. Inspect physical and mechanical condition.
 - b. Inspect anchorage, alignment, grounding, and clearances.
 - c. Verify that the unit is clean.
 - d. Verify blade alignment, blade penetration, travel stops, and mechanical operation.

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- 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.

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- 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.

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- 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.

3.6 ADJUSTING

- A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.
- B. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573 "Overcurrent Protective Device Coordination Study."

END OF SECTION

**SECTION 26 4313 - SURGE PROTECTION FOR LOW-VOLTAGE ELECTRICAL
POWER CIRCUITS**

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes 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.

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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.

PART 2 PRODUCTS

2.1 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.

2.2 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.

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- 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.

2.3 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.

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- 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.

2.4 ENCLOSURES

- A. Indoor Enclosures: NEMA 250, Type 1.
- B. Outdoor Enclosures: NEMA 250, Type 3R

2.5 CONDUCTORS AND CABLES

- A. Power Wiring: Same size as SPD leads, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

PART 3 EXECUTION

3.1 INSTALLATION

- A. Comply with NECA 1.
- B. 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

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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."

3.2 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative.
 - 1. Compare equipment nameplate data for compliance with Drawings and 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.

3.3 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.

3.4 DEMONSTRATION

- A. Train Owner's maintenance personnel to operate and maintain SPDs.

END OF SECTION

SECTION 26 5119 - LED INTERIOR LIGHTING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes 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.

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- 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.

PART 2 PRODUCTS

2.1 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."

2.2 LUMINAIRE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. 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.

2.3 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.

2.4 METAL FINISHES

- A. Variations in finishes are unacceptable in the same piece. Variations in finishes of adjoining components are acceptable if they are within the range of approved Samples and if they can be and are assembled or installed to minimize contrast.

2.5 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.

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- C. Wires: ASTM A 641/A 641 M, Class 3, soft temper, zinc-coated steel, 12 gage.
- D. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.
- E. Hook Hangers: Integrated assembly matched to luminaire, line voltage, and equipment with threaded attachment, cord, and locking-type plug.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before luminaire installation. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 TEMPORARY LIGHTING

- A. If approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is sufficiently complete, clean luminaires used for temporary lighting and install new lamps.

3.3 INSTALLATION

- A. Comply with NECA 1.
- B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.
- C. Install lamps in each luminaire.
- D. Supports:
 - 1. Sized and rated for luminaire weight.
 - 2. Able to maintain luminaire position after cleaning and 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.

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- 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.

3.4 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
 - 2. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.
- B. Luminaire will be considered defective if it does not pass operation tests and inspections.
- C. Prepare test and inspection reports.

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3.6 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."

3.7 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

SECTION 26 5219 - EMERGENCY AND EXIT LIGHTING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Emergency lighting units.
 - 2. Exit signs.
 - 3. Luminaire supports.

1.3 DEFINITIONS

- A. CCT: Correlated color temperature.
- B. CRI: Color Rendering Index.
- C. Emergency Lighting Unit: A lighting unit with internal or external emergency battery powered supply and the means for controlling and charging the battery and unit operation.
- D. Fixture: See "Luminaire" Paragraph.
- E. Lumen: Measured output of lamp and luminaire, or both.
- F. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of emergency lighting unit, exit sign, and emergency lighting support.
 - 1. Include data on features, accessories, and finishes.
 - 2. Include physical description of the unit and dimensions.
 - 3. Battery and charger for light units.
 - 4. Include life, output of luminaire (lumens, CCT, and CRI), and energy-efficiency data.
 - 5. Include photometric data and adjustment factors based on laboratory tests, complying with IES LM-45, for each luminaire type.

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- 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.

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- 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.

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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.

PART 2 PRODUCTS

2.1 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."

2.2 GENERAL REQUIREMENTS FOR EMERGENCY LIGHTING

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. NRTL Compliance: Fabricate and label emergency lighting units, exit signs, and batteries to comply with UL 924.
- C. Comply with NFPA 70 and NFPA 101.
- D. 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.

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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.

2.3 EXIT SIGNS

- A. General Requirements for Exit Signs: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.
- B. Internally Lighted Signs:
 1. Lamps for AC Operation: LEDs; 50,000 hours minimum rated lamp life.
 2. Self-Powered Exit Signs (Battery Type): Internal emergency power unit.

2.4 MATERIALS

- A. Metal Parts:
 1. Free of burrs and sharp corners and edges.
 2. Sheet metal components shall be steel unless otherwise indicated.
 3. Form and support to prevent warping and sagging.
- B. Doors, Frames, and Other Internal Access:
 1. Smooth operating, free of light leakage under operating conditions.
 2. Designed to permit relamping without use of tools.
 3. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.
- C. Diffusers and Globes:
 1. 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.

2.5 METAL FINISHES

- A. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

2.6 LUMINAIRE SUPPORT COMPONENTS

- A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.
- B. Support Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for conditions affecting performance of luminaires.
- B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before luminaire installation.
- C. Examine walls, floors, roofs, and ceilings for suitable conditions where emergency lighting luminaires will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Comply with NECA 1.
- B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.
- C. Install lamps in each luminaire.
- D. Supports:
 - 1. Sized and rated for luminaire and emergency power unit weight.
 - 2. Able to maintain luminaire position when testing emergency power unit.
 - 3. Provide support for luminaire and emergency power unit without causing deflection of ceiling or wall.
 - 4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire and emergency power unit weight and vertical force of 400 percent of luminaire weight.
- E. Wall-Mounted Luminaire Support:

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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.

3.3 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
1. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.
- B. Luminaire will be considered defective if it does not pass operation tests and inspections.
- C. Prepare test and inspection reports.

3.5 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.

3.6 ADJUSTING

- A. Adjustments: Within 12 months of date of Substantial Completion, provide on-site visit to do the following:
1. Inspect all luminaires. Replace lamps, emergency power units, batteries, signs, or luminaires that are defective.
 - a. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
 2. Conduct short-duration tests on all emergency lighting.

END OF SECTION

SECTION 26 5613 - LIGHTING POLES AND STANDARDS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. 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.

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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.

PART 2 PRODUCTS

2.1 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.

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- 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.

2.2 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.

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- 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.

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- 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.

2.3 POLE ACCESSORIES

- A. Base Covers: Manufacturers' standard metal units, finished same as pole, and arranged to cover pole's mounting bolts and nuts.

2.4 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.

2.5 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.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

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- 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.

3.2 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.

3.3 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.

3.4 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.

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- 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.

3.5 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.

3.6 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.7 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

SECTION 26 5619 - LED EXTERIOR LIGHTING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Exterior solid-state luminaires that are designed for and exclusively use LED lamp technology.
 - 2. Luminaire supports.
 - 3. Luminaire-mounted photoelectric relays.
- B. Related Requirements:
 - 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.

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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.

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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.

PART 2 PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
- B. Seismic Performance: Luminaires and 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."

2.2 LUMINAIRE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. NRTL Compliance: Luminaires 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.

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- 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.

2.3 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.

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- H. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.
 - 1. Label shall include the following lamp characteristics:
 - a. "USE ONLY" and include specific lamp type.
 - b. Lamp diameter, shape, size, wattage and coating.
 - c. CCT and CRI for all luminaires.

2.4 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.

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- a. Color: As selected by Architect from manufacturer's full range.

2.5 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.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for luminaire electrical conduit to verify actual locations of conduit connections before luminaire installation.
- C. Examine walls, roofs, and canopy ceilings for suitable conditions where luminaires will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 TEMPORARY LIGHTING

- A. If approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is substantially complete, clean luminaires used for temporary lighting and install new lamps.

3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Comply with NECA 1.
- B. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.
- C. Install lamps in each luminaire.
- D. Fasten luminaire to structural support.
- 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.

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- 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.

3.4 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."

3.5 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."

3.6 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.

3.7 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.8 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.

3.9 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain luminaires.

3.10 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

SECTION 27 0500 - COMMON WORK REQUIREMENTS FOR COMMUNICATIONS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General Conditions, Supplemental General Conditions, and Division 1 Specification Sections apply to all Sections of Division 27.
- B. The requirements listed under General Conditions and Supplementary Conditions and General Requirements are applicable to this section and all subsequent sections of Division 27 and form a part of the contract.
- C. Division 1, Coordination for additional requirements.
- D. Division 1, Cutting and Patching, for additional requirements.
- E. Division 1, Submittals, for additional requirements.
- F. Division 7, Fire stopping, for additional requirements.
- G. Division 7, Joint Sealants, for additional requirements.
- H. Division 9, Painting, for additional requirements.
- I. Division 31, Site Work for Trenching, Backfilling, and Compaction requirements.
- J. State of NM DoIT – Standard for Building and Campus Distribution Systems

1.2 SUMMARY

- A. This Section includes general administrative and procedural requirements of electrical installations. The following administrative and procedural requirements are included in this Section to expand the requirements specified in Division 1:
 - 1. Submittals
 - 2. Coordination Drawings
 - 3. Record Documents
 - 4. Maintenance Manuals
 - 5. Rough-Ins
 - 6. Electrical Installations
 - 7. Cutting and Patching

1.3 ELECTRICAL DIVISION INDEX

Section 27 0500, Common Work Results for Communications
Section 27 0526, Grounding and Bonding for Communications Systems
Section 27 0528, Pathways for Communications Systems
Section 27 0536, Cable Trays for Communications Systems
Section 27 0544, Sleeves And Sleeve Seals for Communications Systems
Section 27 1100, Communications Equipment Room Fittings
Section 27 1300, Communications Backbone Cabling
Section 27 1500, Communications Horizontal Cabling
Section 27 1622, Cabling for A/V Systems
Section 27 4100, Audio-Visual Systems
SoNM Wire Spec (color) Final 08_4_2017

1.4 DEFINITIONS

- A. ARC: Aluminum rigid conduit.
- B. BCT: Bonding conductor for telecommunications.
- C. BICSI: Building Industry Consulting Service International.
- D. Consolidation Point: A location for interconnection between horizontal cables extending from building pathways and horizontal cables extending into furniture pathways.
- E. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.
- F. EMI: Electromagnetic interference.
- G. EMT: Electrical metallic tubing.
- H. GRC: Galvanized rigid steel conduit.
- I. IDC: Insulation displacement connector.
- J. IMC: Intermediate metal conduit.
- K. Inter-building Backbone cable: UTP, optical fiber, and coaxial cable that connects telecommunications rooms that are in separate buildings.
- L. Intra-building Backbone cable: UTP, optical fiber, and coaxial cable that connects telecommunications rooms that are within the same buildings.

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- M. LAN: Local area network.
- N. MUTOA: Multiuser telecommunications outlet assembly, a grouping in one location of several telecommunications outlets/connectors.
- O. Outlet/Connectors: A connecting device in the work area on which horizontal cable or outlet cable terminates.
- P. TBB: Telecommunications Bonding Backbone.
- Q. TGB: Telecommunications grounding busbar. The term used synonymously with BCT.
- R. TMGB: Telecommunications main grounding busbar.
- S. TR: Telecommunications Room.
- T. RCDD: Registered Communications Distribution Designer.
- U. UTP: Unshielded twisted pair.

1.5 STANDARDS AND CODES

- A. Telecommunications design and installations shall adhere with industry standards, including but not limited to:
 - 1. NFPA-70, National Electrical Code
 - 2. NFPA-72, National Fire Alarm and Signaling Code
 - 3. BICSI Telecommunications Distribution Methods Manual (TDMM), 14th Edition
 - 4. ANSI/TIA/EIA-568-C: Generic Telecommunications Cabling for Customer Premises
 - 5. ANSI/TIA/EIA-568-C: Commercial Building Telecommunications Cabling Standard
 - 6. ANSI/TIA/EIA-568-C: Commercial Building Telecommunications Cabling Standard, Part 2: Balanced Twisted Pair Cabling
 - 7. ANSI/TIA/EIA-568-C: Optical Fiber Cabling Components Standard
 - 8. ANSI/TIA/EIA-TIA-569-C: Commercial Building Standard for Telecommunications Pathways and Spaces
 - 9. ANSI/TIA/EIA-598-D: Color Coding of Fiber Optic Cables
 - 10. ANSI/TIA/EIA-606-B: The Administration Standard for the Telecommunications Infrastructure of Commercial Building
 - 11. ANSI/TIA/EIA-607-B: Commercial Building Grounding and Bonding Requirements for Telecommunications
 - 12. ANSI/TIA/EIA-758-B: Customer Owned Outside Plant Telecommunications Cabling Standard
 - 13. ANSI/TIA/EIA-526-14-C: Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant.

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- B. Comply with local AHJ codes and requirements in addition to these listed.
- C. Above referenced standards are to be most current version published at the time specifications are issued, including addendums, and technical services bulletins.

1.6 RECORD DRAWINGS

- A. Maintain a complete and accurate set of marked up blue-line prints showing information on the installed location and arrangement of all electrical work, and in particular, where changes were made during construction. Use red color to indicate additions or corrections to prints, green color to indicate deletions, and yellow color to indicate items were installed as shown. Keep record drawings accurate and up-to-date throughout the construction period. Record drawings may be reviewed and checked by the Architect, and Owner's Representative, during the construction and in conjunction with the review and approval of monthly pay requests. Include copies of all addenda, RFI's, bulletins, and change orders neatly taped or attached to the record drawing set. Transmit drawings to the Architect, and Owner's Representative, at the conclusion of the project for delivery to the Owner's Representative.
- B. Prepare record documents in accordance with the requirements in Division 1, Section "PROJECT CLOSEOUT." In addition to the requirements specified in Division 1, indicate installed conditions for:
 - 1. Major raceway systems, size and location, for both exterior and interior.
 - 2. Equipment locations (exposed and concealed), dimensioned from prominent building lines.
 - 3. Approved substitutions, Contract Modifications, and actual equipment and materials installed.

1.7 QUALIFICATIONS

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

1.8 SUBSTITUTIONS

- 1. Refer to Division 01 for Substitution procedures.

1.9 PRIOR APPROVAL

- A. Prior Approval not permitted. Substitution prior to bid as required by Division 01.

1.10 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.

1.11 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.

1.12 SUBMITTALS

- A. The Contractor shall submit submittal brochures of equipment and materials to be furnished under Division 27.
- 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

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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 Architect, Engineer, and Owner's Representative, with the shop drawing submittals of the substituted. Failure to comply with this requirement will result in the shop drawings being returned unchecked.
- 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. The Contractor shall submit amount of copies and type, electronic or hard copies, of submittal brochures for review per Division 1 requirements. Brochures shall be submitted within thirty (30) days after contract award. Copies of all submittals will be retained by the Architect, Engineer, and Owner's Representative. Additional copies of submittals, if required by the Contractor, shall be reproduced by the Contractor from the reviewed and marked sets returned to the Contractor.

1.13 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:

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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.
3. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
4. Servicing instructions and schedules.

1.14 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.

1.15 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.

1.16 DRAWINGS AND SPECIFICATIONS

- A. Electrical drawings are diagrammatic, but shall be followed as closely as actual construction and

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work of the other sections shall permit. Size and location of equipment is drawn to scale wherever possible. Do not scale from electrical drawings.

- B. Drawings and specifications are for the assistance and guidance of the Contractor. Exact locations, distances, and levels will be governed by the building. The Contractor shall make use of data in all the Contract Documents to verify information at the building site.
- C. In any case where there appears to be a conflict between that which is shown on the electrical drawings, and that shown in any other part of the Contract Documents, the Contractor shall notify and secure directions from the Architect.
- D. Drawings and specifications are intended to complement each other. Where a conflict exists between the requirements of the drawings and/or the specifications, request clarification. Do not proceed with work without direction.
- E. The Architect shall interpret the drawings and the specifications. The Architect's interpretation as to the true intent and meaning thereof and the quality, quantity, and sufficiency of the materials and workmanship furnished thereunder 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.

1.17 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.

1.18 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.

1.19 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

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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 27 shall be provided with at least a full two (2) year parts and labor warranty.

PART 2 PRODUCTS

2.1 QUALITY OF MATERIALS

- A. All equipment and materials shall be new, and shall be the standard product of manufacturers regularly engaged in the production of electrical equipment, and shall be the manufacturer's latest design. Specific equipment, shown in schedules on drawings and specified herein, is to set forth a standard of quality and operation.
- B. Hazardous or Environmentally Damaging Materials: Products shall not contain asbestos, mercury, PCBs, or other materials harmful to people or the environment.

2.2 ALTITUDE RATINGS

- A. Unless otherwise noted, all specified equipment capacities are for an altitude of 7,200 feet above sea level and adjustments to manufacturer's ratings must be made accordingly.

2.3 EQUIPMENT REQUIREMENTS

- A. The electrical requirements for equipment specified or indicated on the drawings are based on information available at the time of design. If equipment furnished for installation has electrical requirements other than those indicated on the electrical drawings, make all adjustments to wire and conduit size, controls, over current protection and installation as required to accommodate the equipment supplied. Delineate all adjustments to the drawings reflecting the electrical system in a submittal to the Contract Administrator immediately upon knowledge of the required adjustment.
- B. Approved Equipment and Conductors: All electrical equipment and its components and materials shall meet all applicable UL criteria and bear the appropriate label of the UL, and shall be listed and labeled by a nationally recognized testing laboratory (NRTL). The NRTL shall be listed by the federal occupational safety and health administration.

PART 3 EXECUTION

3.1 COOPERATION WITH OTHER TRADES

- A. Coordinate all work so that the construction operations can proceed without harm to the Owner from interference, delay, or absence of coordination. The Contractor shall be responsible for the size and accuracy of all openings.

3.2 DRAWINGS

- A. The electrical drawings show the general arrangement of all special systems, equipment, etc., and shall be followed as closely as actual building construction and work of other trades will permit. Whenever discrepancies occur between plans and specifications, the most stringent shall govern. All Contract Documents shall be considered as part of the work. Coordinate with architectural, mechanical, and structural drawings. Because of the small scale of the electrical drawings, it is not possible to indicate all offsets, fittings and accessories which may be required. Provide all fittings, boxes, and accessories as may be required to meet actual conditions. Should conditions necessitate a rearrangement of equipment, such departures and the reasons therefore, shall be submitted by the Contractor for review in the form of detailed drawings showing the proposed changes. No changes shall be made without the prior written approval. All changes shall be marked on record drawings.
- B. Should any doubt or question arise in respect to the true meaning of the drawings or specifications, the question shall be submitted in writing.
- C. Installation of all equipment shall be arranged to provide all clearances required for equipment operation, service, and maintenance, including minimum clearance, as defined by the National Electrical Code (NEC).
- D. The Contractor's attention is directed to the unique architectural design features and consideration associated with this facility which will require significantly greater levels of coordination and cooperation for the work furnished and installed under Division 27 with the associated architectural, structural, and mechanical work than is normally necessary for a more typical facility.
- E. The installation of all concealed communication systems shall be carefully arranged to fit within the available space without interference with adjacent structural, mechanical and other electrical systems.

3.3 ELECTRICAL INSTALLATIONS

- A. General: Sequence, coordinate, and integrate the various elements of the communication systems, materials, and equipment. Comply with the following requirements:
 - 1. Coordinate electrical and communication systems, equipment, and materials installation with all other building components.
 - 2. Verify all dimensions by field measurements.

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3. Arrange for chases, slots, and openings in all other building components during progress of construction, to allow for electrical and communication systems installation.
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 communication systems 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 communication systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.
8. Install systems, materials, and equipment to conform with approved submittal data, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer conflict to the Architect.
9. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components.
10. Install communication systems 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 access panel or doors where units are concealed behind finished surfaces.
12. Install systems, materials, and equipment giving right-of-way priority to systems requiring installation at a specified slope.

3.4 FIELD MEASUREMENTS

- A. No extra compensation shall be claimed or allowed due to differences between actual dimensions, including dimensions of equipment, fixtures and materials furnished, and those indicated on the drawings. Contractor shall examine adjoining work, and shall report any work which must be corrected. Review of submittal data in accordance with paragraph "Submittals" shall in no manner relieve the Contractor of responsibility for the proper installation of the electrical work within the available space. Installation of equipment and systems within the building space shall be carefully coordinated by the Contractor.

3.5 EQUIPMENT SUPPORT

- A. Provide support for equipment to the building structure. Provide all necessary structures, inserts, sleeves, firestops and hanging devices for installation of equipment. Coordinate installation of devices. Verify with the Architect that the devices and supports are adequate as intended and do not overload the building's structural components in any way.

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3.6 PAINTING

- A. All finish painting of communication systems and equipment will be under "Painting," unless equipment is hereinafter specified to be painted.
- B. All equipment shall be provided with factory applied standard finish, unless otherwise specified.
- C. Touch-Up: If the factory finish on any equipment is damaged in shipment or during construction of the building, the equipment shall be refinished to the satisfaction of the Architect, and Owner's Representative.

3.7 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 communication systems equipment shall be stored in a protected weatherproof enclosure prior to installation within the building, or shall be otherwise protected from the weather in a suitable manner approved by the Architect, and Owner's Representative.
- C. The Contractor shall provide protection for all work and shall be responsible for all damage done to property, equipment and materials. Storage of materials within the building shall be approved by the Architect, and Owner's Representative prior to such storage.
- D. Conduit openings shall be closed with caps or plugs, or covered to prevent lodgment of dirt or trash during the course of installation. At the completion of the work, fixtures, equipment and materials shall be cleaned and polished thoroughly and delivered in a condition satisfactory to the Architect.

3.8 EXCAVATION

- A. Provide all excavation, trenching and backfilling required.
- B. Slope sides of excavations to comply with codes and ordinances. Shore and brace as required for stability of excavation.

3.9 ERECTION OF METAL SUPPORTS AND ANCHORAGE

- A. Cut, fit, and place miscellaneous metal fabrications accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- B. Field Welding: Comply with AWS "Structural Welding Code."

3.10 ERECTION OF WOOD SUPPORTS AND ANCHORAGE

- A. Cut, fit, and place wood grounds, nailers, blocking, and anchorage accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- B. Select fastener sizes that will not penetrate members where opposite side will be exposed to view or will receive finish materials. Make tight connections between members. Install fasteners without splitting wood members.
- C. Attach to substrates as required to support applied loads.

3.11 APPLICATION OF JOINT SEALERS

- A. General: Comply with joint sealer manufacturer's printed application instructions applicable to products and applications indicated, except where more stringent requirements apply.
 - 1. Comply with recommendations of ASTM C 962 for use of elastomeric joint sealants.
 - 2. Comply with recommendations of ASTM C 790 for use of acrylic-emulsion joint sealants.
- B. Immediately after sealant application and prior to time shinning or curing begins, tool sealants to form smooth, uniform beads; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint. Remove excess sealants from surfaces adjacent to joint. Do not use tooling agents that discolor sealants or adjacent surfaces or are not approved by sealant manufacturer.
- C. Firestopping Sealant: Provide sealant, including forming, packing, and other accessory materials, to fill openings around electrical services penetrating floors and walls, to provide fire-stops with fire-resistance ratings indicated for floor or wall assembly in which penetration occurs. Comply with installation requirements established by testing and inspecting agency.

3.12 INSTALLATION OF ACCESS DOORS

- A. Set frames accurately in position and securely attached to supports, with face panels plumb and level in relation to adjacent finish surfaces.
- B. Adjust hardware and panels after installation for proper operation.

3.13 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.

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- b. Remove and replace Work not conforming to requirements of the Contract Documents.
 - c. Remove samples of installed Work as specified for testing.
 - d. Install equipment and materials in existing structures.
 - e. Upon written instructions from the Contracting Officer, uncover and restore Work to provide for Contracting Officer observation of concealed Work.
2. Cut, remove, and legally dispose of selected communication systems equipment, components, and materials as indicated, including but not limited to removal of items indicated to be removed and items made obsolete by the new Work.
 3. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.
 4. Provide and maintain temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to adjacent areas.
 5. During cutting and patching operations, protect adjacent installations.
 6. Patch existing finished surfaces and building components using new materials matching existing materials and experienced installers.

3.14 MANUFACTURER'S INSTRUCTIONS

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

3.15 TESTS

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

3.16 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 communication systems and equipment for a period of (3) days of eight (8) hours each. During this period, the Contractor shall instruct the Owner or his

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

- D. The Contractor shall video tape the instruction and training sessions using a DVD recorder, and at the completion and acceptance (by Owner and Architect) of the training sessions, the Contractor shall submit (4) copies of the video the recordings.

3.17 CERTIFICATIONS

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

3.18 OPERATION PRIOR TO ACCEPTANCE

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

3.19 SITE VISITS AND OBSERVATION OF CONSTRUCTION

- A. The Architect/Engineer will make periodic visits to the project site at various stages of construction in order to observe the progress and quality of various aspects of the Contractor's work, in order to determine in general if such work is proceeding in accordance with the Contract Documents. This observation by the Architect/Engineer however, shall in no way release the Contractor from his complete responsibility to supervise, direct, and control all construction work and activities, nor shall the Architect/Engineer have authority over, or a responsibility to means, methods, techniques, sequences, or procedures of construction provided by the Contractor or for safety precautions and programs, or for failure by the Contractor to comply with all law, regulations, and codes.

END OF SECTION 27 0500

SECTION 27 0526 - GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. State of NM DoIT – Standard for Building and Campus Distribution Systems

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 rods.

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2. Ground and roof rings.
 3. BCT, TMGB, TGBs, and routing of their bonding conductors.
- B. Qualification Data: For Installer, installation supervisor, and field inspector.
- C. Qualification Data: For testing agency and testing agencies field supervisor.
- D. 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 Division 1 to 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 QUALITY ASSURANCE

- A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff. (submit qualifications)
1. Layout Responsibility: Preparation of Shop Drawings and Cabling Administration Drawings, Cabling Administration Drawings and field testing program development by an RCDD.
 2. Installation Supervision: Installation shall be under the direct supervision of a Registered Technician, or Level 2 Installer, who shall be present at all times when Work of this Section is performed at Project site.
 3. Testing Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.
- B. Testing Agency Qualifications: An NRTL.
1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.
- C. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
1. Flame-Spread Index: 25 or less.
 2. Smoke-Developed Index: 50 or less.
- 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.

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- E. Telecommunications Pathways and Spaces: Comply with TIA/EIA-569-C.
- F. Grounding: Comply with TIA-607-B.

1.8 QUALIFICATIONS

- A. Communications Cabling: The Contractor shall have (5) five years of documented experience performing cable placement, splicing, termination, connecting, and testing for each of the media types and (3) three years of applicable experience with the proposed system manufacturer. In the case of newer technologies that do not have a (3) three year history, the Contractor shall have documented experience for at least half of the lifetime of the new technology. The approved contractor shall, at a minimum, maintain a ratio of one manufacturer or BICSI certified installer for every two non-certified installers assigned to the project.
- B. The contractor shall have on staff a BICSI Certified RCDD as a permanent employee. This staff member shall have been on staff for a minimum of (1) one year prior to the date of this projects release for bid.
- C. The contractor shall have on staff at least (1) one BICSI Certified Technician and this staff member shall have been a full time employee for no less than (1) one year prior to the date of this projects release for bid. A BICSI Certified Technician shall be employed as the on-site Field Supervisor for this project.
- D. The contractor shall provide resumes for the Project Manager, Supervisors and any skilled technicians or installers. Each resume shall include applicable certification documents provided by the manufacturer or BICSI.
 - 1. Project Manager, Supervisors, and Principal Skilled Technicians: minimum of (5) five years' experience in like work.
 - 2. Category 6 Unshielded Twisted Pair and Fiber Optic Cable Technicians: documented training, licensing, and/or certification for the types of media specified, as applicable as well as certification from the manufacturer of the solution chosen by the owner.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with UL 467 for grounding and bonding materials and equipment.
- C. Comply with TIA-607-B.

2.2 CONDUCTORS

- A. 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. Harger Lightning and Grounding.
 - 2. Panduit Corp.
 - 3. Tyco Electronics Corp.
 - 4. Owner or Consultant approved equal.
- B. Comply with UL 486A-486B.
- C. 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.
- D. Cable Tray Grounding Jumper:
 - 1. Not smaller than No. 6 AWG and not longer than 12 inches (300 mm). 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.
- E. 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 kmils (14.2 sq. mm), 14 strands of No. 17 AWG conductor, and 1/4 inch (6.3 mm) in diameter.
 - 5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
 - 6. Bonding Jumper: Tinned-copper tape, braided conductors terminated with two-hole copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.

2.3 CONNECTORS

- A. Irreversible connectors listed for the purpose. Listed by an NRTL as complying with NFPA 70 for specific types, sizes, and combinations of conductors and other items connected. Comply with UL 486A-486B.
- B. Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

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1. Burndy; Part of Hubbell Electrical Systems.
 2. Chatsworth Products, Inc.
 3. Harger Lightning and Grounding.
 4. Panduit Corp.
 5. Tyco Electronics Corp.
 6. Owner or Consultant approved equal.
- C. 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.
- D. Signal Reference Grid Connectors: Combination of compression wire connectors, access floor grounding clamps, bronze U-bolt grounding clamps, and copper split-bolt connectors, designed for the purpose.
- E. Busbar Connectors: Cast silicon bronze, solderless compression or exothermic-type, mechanical connector; with a long barrel and two holes spaced on 5/8- or 1-inch (15.8- or 25.4-mm) centers for a two-bolt connection to the busbar.
- F. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

2.4 GROUNDING BUSBARS

- A. 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. Chatsworth Products, Inc.
 2. Harger Lightning and Grounding.
 3. Panduit Corp.
 4. Owner or Consultant approved equal.
- B. TMGB: Predrilled, wall-mounted, rectangular bars of hard-drawn solid copper, 1/4 by 4 inches (6.3 by 100 mm) in cross section, length as indicated on Drawings. The busbar shall be NRTL listed for use as TMGB and shall comply with TIA-607-B.
1. Predrilling shall be with holes for use with lugs specified in this Section.
 2. Mounting Hardware: Stand-off brackets that provide a 4-inch (100-mm) clearance to access the rear of the busbar. Brackets and bolts shall be stainless steel.
 3. Stand-off insulators for mounting shall be Lexan or PVC. Comply with UL 891 for use in 600-V switchboards, impulse tested at 5000 V.
- C. TGB: Predrilled rectangular bars of hard-drawn solid copper, 1/4 by 2 inches (6.3 by 50 mm) in cross section, length as indicated on Drawings. The busbar shall be for wall mounting, shall be NRTL listed as complying with UL 467, and shall comply with TIA-607-B.

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1. Predrilling shall be with holes for use with lugs specified in this Section.
 2. Mounting Hardware: Stand-off brackets that provide at least a 2-inch (50-mm) clearance to access the rear of the busbar. Brackets and bolts shall be stainless steel.
 3. Stand-off insulators for mounting shall be Lexan or PVC. Comply with UL 891 for use in 600-V switchboards, impulse tested at 5000 V.
- D. Rack and Cabinet Grounding Busbars: Rectangular bars of hard-drawn solid copper, accepting conductors ranging from No. 14 to No. 2/0 AWG, NRTL listed as complying with UL 467, and complying with TIA-607-B. Predrilling shall be with holes for use with lugs specified in this Section.
1. Cabinet-Mounted Busbar: Terminal block, with stainless-steel or copper-plated hardware for attachment to the cabinet.
 2. Rack-Mounted Horizontal Busbar: Designed for mounting in 19- or 23-inch (483- or 584-mm) equipment racks. Include a copper splice bar for transitioning to an adjoining rack, and stainless-steel or copper-plated hardware for attachment to the rack.
 3. Rack-Mounted Vertical Busbar: 72 or 36 inches (1827 or 914 mm) long, with stainless-steel or copper-plated hardware for attachment to the rack.

2.5 IDENTIFICATION

- A. Comply with requirements for identification products in Section 270553 "Identification for Communications Systems."
- B. 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. Brother International Corporation.
 2. HellermannTyton.
 3. Panduit Corp.
 4. Owner or Consultant approved equal.
- C. Comply with TIA/EIA-606-B and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.
- D. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch (10 mm). Overlay shall provide a weatherproof and UV-resistant seal for label.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Examine the ac grounding electrode system and equipment grounding for compliance with requirements for maximum ground-resistance level and other conditions affecting performance of grounding and bonding of the electrical system.

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- 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.

3.2 INSTALLATION

- A. Bonding shall include the ac utility power service entrance, the communications cable entrance, and the grounding electrode system. The bonding of these elements shall form a loop so that each element is connected to at least two others.
- B. Comply with NECA 1.
- C. Comply with TIA-607-B.

3.3 APPLICATION

- A. Conductors: Install solid conductor for No. 8 AWG and smaller and stranded conductors for No. 6 AWG and larger unless otherwise indicated.
 - 1. The bonding conductors between the TGB and structural steel of steel-frame buildings shall not be smaller than No. 6 AWG.
 - 2. The bonding conductors between the TMGB and structural steel of steel-frame buildings shall not be smaller than No. 6AWG.
- 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 (900 mm).
- 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.

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3. Support at not more than 36-inch (900-mm) intervals.
4. Install grounding and bonding conductors in 3/4-inch (21-mm) PVC conduit until conduit enters a telecommunications room. The grounding and bonding conductor pathway through a plenum shall be in EMT. Conductors shall not be installed in EMT unless otherwise indicated.
 - a. If a grounding and bonding conductor is installed in ferrous metallic conduit, bond the conductor to the conduit using a grounding bushing that complies with requirements in Section 270528 "Pathways for Communications Systems," and bond both ends of the conduit to a TGB.

3.4 GROUNDING ELECTRODE SYSTEM

- A. The BCT between the TMGB and the ac service equipment ground shall not be smaller than No. 1/0 AWG.

3.5 GROUNDING BUSBARS

- A. Indicate locations of grounding busbars on Drawings. Install busbars horizontally, on insulated spacers 2 inches (50 mm) minimum from wall, 12 inches (300 mm) above finished floor unless otherwise indicated.
- 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.

3.6 CONNECTIONS

- A. Bond metallic equipment in a telecommunications equipment room to the grounding busbar in that room, using equipment grounding conductors not smaller than No. 6 AWG.
- B. Stacking of conductors under a single bolt is not permitted when connecting to busbars.
- C. Assemble the wire connector to the conductor, complying with manufacturer's written instructions and as follows:
 1. Use crimping tool and the die specific to the connector.
 2. Pretwist the conductor.
 3. Apply an antioxidant compound to all bolted and compression connections.
- D. Primary Protector: Bond to the TMGB with insulated bonding conductor.
- E. 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 kmils/linear foot (1 sq. mm/linear meter) of conductor length, up to a maximum size of No. 3/0 AWG unless otherwise indicated.

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- F. Telecommunications Enclosures and Equipment Racks: Bond metallic components of enclosures to the telecommunications bonding and grounding system. Install rack grounding busbar unless the enclosure and rack are manufactured with the busbar. 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 (1200-mm) 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.
- M. Towers and Antennas:
 - 1. Ground Ring: Buried at least 30 inches (760 mm) below grade and at least 24 inches (610 mm) from the base of the tower or mounting.
 - 2. Bond each tower base and metallic frame of a dish to the ground ring, buried at least 18 inches (460 mm) below grade.
 - 3. Bond the ground ring and antenna grounds to the equipment room TMGB or TGB, buried at least 30 inches (760 mm) below grade.
 - 4. Bond metallic fences within 6 feet (1.8 m) of towers and antennas to the ground ring, buried at least 18 inches (460 mm) below grade.
 - 5. Special Requirements for Roof-Mounted Towers:
 - a. Roof Ring: Meet requirements for the ground ring except the conductors shall comply with requirements in Section 264113 "Lightning Protection for Structures."
 - b. Bond tower base footings steel, the TGB in the equipment room, and antenna support guys to the roof ring.

- c. Connect roof ring to the perimeter conductors of the lightning protection system.
- 6. Waveguides and Coaxial Cable:
 - a. Bond cable shields at the point of entry into the building to the TGB and to the cable entrance plate, using No. 2 AWG bonding conductors.
 - b. Bond coaxial cable surge arrester to the ground or roof ring using bonding conductor size recommended by surge-arrester manufacturer.

3.7 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

- A. Duct-Bank Grounding Conductor: Bury 12 inches (300 mm) above duct bank when indicated as part of duct-bank installation.
- B. Comply with IEEE C2 grounding requirements.
- C. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches (100 mm) extends above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches (50 mm) above to 6 inches (150 mm) below concrete. Seal floor opening with waterproof, nonshrink grout.
- D. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect grounding conductors to cable armor and cable shields according to written instructions by manufacturer of splicing and termination kits.

3.8 IDENTIFICATION

- A. Labels shall be preprinted or computer-printed type.
 - 1. Label TMGB(s) with "fs-TMGB," where "fs" is the telecommunications space identifier for the space containing the TMGB.
 - 2. Label TGB(s) with "fs-TGB," where "fs" is the telecommunications space identifier for the space containing the TGB.
 - 3. Label the BCT and each telecommunications backbone conductor at its attachment point: "WARNING! TELECOMMUNICATIONS BONDING CONDUCTOR. DO NOT REMOVE OR DISCONNECT!"

3.9 FIELD QUALITY CONTROL

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

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- C. 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 and in each TGB. Maximum acceptable ac current level is 1 A.
- D. Excessive Ground Resistance: If resistance to ground at the BCT exceeds 5 ohms, notify Architect promptly and include recommendations to reduce ground resistance.
- E. Grounding system will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.

END OF SECTION

SECTION 27 0528 - PATHWAYS FOR COMMUNICATIONS SYSTEMS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. State of NM DoIT – Standard for Building and Campus Distribution Systems

1.2 SUMMARY

- A. Section Includes:
 - 1. Metal conduits and fittings.
 - 2. Nonmetallic conduits and fittings.
 - 3. Metallic surface pathways.
 - 4. Hooks.
 - 5. Boxes, enclosures, pedestals and cabinets.
 - 6. Handholes and boxes for exterior underground cabling.
- B. Related Requirements:
 - 1. Section 260543 "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks, manholes, and underground utility construction.
 - 2. Section 260533 "Raceways and Boxes for Electrical Systems" for conduits, wireways, surface raceways, boxes, enclosures, cabinets, handholes, and faceplate adapters serving electrical systems.

1.3 DEFINITIONS

- A. ARC: Aluminum rigid conduit.
- B. EMT: Electrical Metallic Tubing
- C. FMC: Flexible Metal Conduit (Shall not be used for Communication pathways)
- D. GRC: Galvanized rigid steel conduit.
- E. IMC: Intermediate metal conduit.
- F. RTRC: Reinforced thermosetting resin conduit.

1.4 ACTION SUBMITTALS

- A. Product data for the following:
 - 1. Surface pathways
 - 2. Wireways and fittings.
 - 3. Tele-power poles.
 - 4. Boxes, enclosures, and cabinets.
 - 5. Underground handholes and boxes.
- B. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff. (submit qualifications)
 - 1. Layout Responsibility: Preparation of Shop Drawings and Cabling Administration Drawings, Cabling Administration Drawings and field testing program development by an RCDD.
 - 2. Installation Supervision: Installation shall be under the direct supervision of a Registered Technician, or Level 2 Installer, who shall be present at all times when Work of this Section is performed at Project site.
 - 3. Testing Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.
- B. Testing Agency Qualifications: An NRTL.
 - 1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.
- C. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - 1. Flame-Spread Index: 25 or less.
 - 2. Smoke-Developed Index: 50 or less.
- 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. Telecommunications Pathways and Spaces: Comply with TIA/EIA-569-C.
- F. Grounding: Comply with TIA-607-B.

1.6 QUALIFICATIONS

- A. Communications Cabling: The Contractor shall have (5) five years of documented experience performing cable placement, splicing, termination, connecting, and testing for each of the media types and (3) three years of applicable experience with the proposed system manufacturer. In the case of newer technologies that do not have a (3) three year history, the Contractor shall have documented experience for at least half of the lifetime of the new technology. The approved contractor shall, at a minimum, maintain a ratio of one manufacturer or BICSI certified installer for every two non-certified installers assigned to the project.
- B. The contractor shall have on staff a BICSI Certified RCDD as a permanent employee. This staff member shall have been on staff for a minimum of (1) one year prior to the date of this projects release for bid.
- C. The contractor shall have on staff at least (1) one BICSI Certified Technician and this staff member shall have been a full time employee for no less than (1) one year prior to the date of this projects release for bid. A BICSI Certified Technician shall be employed as the on-site Field Supervisor for this project.
- D. The contractor shall provide resumes for the Project Manager, Supervisors and any skilled technicians or installers. Each resume shall include applicable certification documents provided by the manufacturer or BICSI.
 - 1. Project Manager, Supervisors, and Principal Skilled Technicians: minimum of (5) five years' experience in like work.
 - 2. Category 6 Unshielded Twisted Pair and Fiber Optic Cable Technicians: documented training, licensing, and/or certification for the types of media specified, as applicable as well as certification from the manufacturer of the solution chosen by the owner.

1.7 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.
- B. Qualification Data: For professional engineer.
- C. Seismic Qualification Certificates: For 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.

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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.

PART 2 PRODUCTS

2.1 METAL CONDUITS AND FITTINGS

- A. 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. AFC Cable Systems, Inc.
 2. Allied Tube & Conduit.
 3. Alpha Wire Company.
 4. Anamet Electrical, Inc.
 5. Electri-Flex Company.
 6. O-Z/Gedney.
 7. Picoma Industries.
 8. Republic Conduit.
 9. Robroy Industries.
 10. Southwire Company.
 11. Thomas & Betts Corporation.
 12. Western Tube and Conduit Corporation.
 13. Wheatland Tube Company.
 14. Owner or Consultant approved equal.
- 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-C.
- C. GRC: Comply with ANSI C80.1 and UL 6.
- D. ARC: Comply with ANSI C80.5 and UL 6A.
- E. IMC: Comply with ANSI C80.6 and UL 1242.
- F. PVC-Coated Steel Conduit: PVC-coated GRC or IMC.
1. Comply with NEMA RN 1.

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2. Coating Thickness: 0.040 inch (1 mm), minimum.
- G. EMT: Comply with ANSI C80.3 and UL 797.
- H. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.
1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 1203 and NFPA 70.
 2. Fittings for EMT:
 - a. Material: Steel or die cast.
 - b. Type: Set screw or 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 (1 mm), with overlapping sleeves protecting threaded joints.
- I. Joint Compound for IMC, GRC, or ARC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 NONMETALLIC CONDUITS AND FITTINGS

- A. 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. AFC Cable Systems, Inc.
 2. Allied Tube & Conduit.
 3. Anamet Electrical, Inc.
 4. Arnco Corporation.
 5. CANTEX Inc.
 6. CertainTeed Corporation.
 7. Condux International, Inc.
 8. Electri-Flex Company.
 9. Kraloy.
 10. Lamson & Sessions; Carlon Electrical Products.
 11. Niedax-Kleinhuis USA, Inc.
 12. RACO; Hubbell.
 13. Thomas & Betts Corporation.
 14. Owner or Consultant approved equal.

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- 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-C.
- C. RNC: Type EPC-40-PVC or Type EPC-80-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.
- D. Rigid HDPE: Comply with UL 651A.
- E. Continuous HDPE: Comply with UL 651A.
- F. RTRC: Comply with UL 2515A and NEMA TC 14.
- G. Fittings: Comply with NEMA TC 3; match to conduit or tubing type and material.
- H. Retain first paragraph below if required for LEED-NC, LEED-CI, or LEED-CS Credit IEQ 4.1. VOC limit is that for PVC welding compounds and adhesive primers for plastic.
- I. Solvent cements and adhesive primers shall have a VOC content of 510 and 550 g/L or less, respectively, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- J. Solvent cements and adhesive primers shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.3 SURFACE METAL PATHWAYS

- A. Description: Galvanized steel with snap-on covers, complying with UL 5.
- B. 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. Mono-Systems, Inc.
 - 2. Niedax-Kleinhuis USA, Inc.
 - 3. Panduit Corp.
 - 4. Wiremold / Legrand.
 - 5. Owner or Consultant approved equal.
- C. Finish: Manufacturer's standard enamel finish in color selected by Architect.
- D. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- E. Comply with TIA-569-C.

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2.4 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-C.
- D. Manufacturers: Subject to compliance with requirements, 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. MonoSystems, Inc., 4 International Dr., Rye Brook, NY 10573 Phone 888.764.7681
- E. Non-Continuous Open Top Cable Support
 - 1. One piece design with integrated wire retainer clip.
 - 2. Radiused edges to prevent damage to cable contents.
 - 3. Steel capable of supporting maximum 70 pounds (H-433) and 60 pounds (H-233) with a safety factor of 1.5.
 - 4. Galvanized or stainless steel finish.
 - 5. Infinitely linkable with zero associated hardware. Shall be capable of linking one-to-the-next without supports, brackets, or additional materials. Tiered in a single column, or back-to-back (J-hook Trees).
 - 6. Accept 3/8" (or 10mm) threaded rod, 12 gauge – 1/4" hanger wire, for attachment to building structure or sub-structure.
 - 7. Holes for attachment to wall surfaces, beams, trusses, and direct attachment to cable trays.
 - 8. J-hook dimensions: H-433, nominally 4" high x 3" deep ; H-233, nominally 2" high x 3" deep.
 - 9. White, red, green, yellow or blue color identifiers for content designation of segregated cables.
 - a. Colored identifiers H-433-CB-WH (white), H-433-CB-RD (red), H-433-CB-GR (green), H-433-CB-YE (yellow), H-433-CB-BL (blue)
 - 10. Manufacturer shall be MonoSystems, Inc.
 - a. H-433-S (galvanized steel) or H-433-SS (304 stainless steel)
 - b. H-233-S (galvanized steel) or H-233-SS (304 stainless steel)
- F. Center Hanger Connector Plate
 - 1. Bracket that allows for back-to-back open top cable support mounting. J-hook Tree construction.
 - 2. Continuous cable division shall be fully maintained within each open top cable support.
 - 3. Fittings shall be manufactured of galvanized steel or stainless steel.

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4. Manufacturer shall be MonoSystems, Inc.
 - a. H-433-H (galvanized steel) or H-433-HSS (stainless steel)
- G. Multi-tier Assembly
 1. Bracket that allows for top-to-bottom non-continuous open top cable support mounting.
 2. Continuous cable division shall be fully maintained within each non-continuous open top cable support.
 3. Fittings shall be manufactured of galvanized steel or stainless steel
 4. Manufacturer shall be MonoSystems, Inc.
 - a. H-433-S (galvanized steel) or H-433-SS (stainless steel)
 - b. H-233-S (galvanized steel) or H-233-SS (stainless steel)
- H. Cable Support Extender (H-CSE-12)
 1. 12” long cable support extender
 2. For the purpose of extending the support platform for cables and wires. Eliminating point loads.
 3. Attaches directly to the H-233 and H-433 without additional hardware.
 4. Does not interfere with J-hook linkability.
 5. Plenum rated, UL listed.
 6. Material: RTP199X127145F (glass filled polypropylene). Listed to UL 2043 and UL94 flame rated.
- I. Beam Clamp Assembly
 1. Beam clamp assembly may attach to top or back of non-continuous open top cable support.
 2. Mounts to standard “H” or “I” beam construction
 - a. H-4333-BC beam clamp
 - b. H-2333-BC beam clamp

2.5 BOXES, ENCLOSURES, CABINETS, PEDESTALS

- A. Description: Enclosures for communications.
- B. 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. 3M
 2. Adalet.
 3. Cooper Technologies Company; Cooper Crouse-Hinds.
 4. EGS/Appleton Electric.

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5. Erickson Electrical Equipment Company.
 6. Hoffman.
 7. Lamson & Sessions; Carlon Electrical Products.
 8. Milbank Manufacturing Co.
 9. Molex; Woodhead Brand.
 10. Mono-Systems, Inc.
 11. O-Z/Gedney.
 12. Old Castle Precast
 13. Quazite:Hubbell Power Systems, Inc.
 14. Pedlock
 15. RACO; Hubbell.
 16. Robroy Industries.
 17. Spring City Electrical Manufacturing Company.
 18. Stahlin Non-Metallic Enclosures.
 19. Thomas & Betts Corporation.
 20. Wiremold / Legrand.
 21. Owner or Consultant approved equal.
- C. General Requirements for Boxes, Enclosures, and Cabinets:
1. Comply with TIA-569-C.
 2. Boxes, enclosures, and cabinets installed in wet locations shall be listed and labeled as defined in NFPA 70, by an NRTL, and marked for use in wet locations.
 3. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
 4. Device Box Dimensions: 4 inches square by 2-1/8 inches deep (100 mm square by 60 mm deep)
 5. Gangable boxes are prohibited.
- D. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.
- E. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy or aluminum, Type FD, with gasketed cover.
- F. Metal Floor Boxes:
1. Material: Cast metal or sheet metal.
 2. Type: Fully adjustable or Semi-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.

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- G. Nonmetallic Floor Boxes: Nonadjustable, round or rectangular.
 - 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.
- H. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- I. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, cast aluminum or galvanized, cast iron with gasketed cover.
- J. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.
- K. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 3R with continuous-hinge cover with flush latch unless otherwise indicated.
 - 1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
 - 2. Nonmetallic Enclosures:
 - a. Material: Fiberglass.
 - b. Finished inside with radio-frequency-resistant paint.
 - 3. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.
- L. Cabinets and Pedestals
 - 1. NEMA 250, Type 3R galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel. Rated for Communications, Multi paired copper.
 - 2. Nonmetallic cabinets or pedestals shall be outdoor rated and listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 3. Basis of Design
 - a. Manufactures:
 - 1) 3M
 - 2) Charles Industries
 - 3) Connector Manufacturing Company
 - 4) Hoffman (nVent)
 - 5) Hubbell
 - 6) Maclean
 - 7) Pedlock
 - 8) Vertiv
 - b. Color: Almond or Beige
 - c. Direct Buried Type
 - d. Pair Count: Up to 600
 - e. Coordinate with Century Link Design Standards for Communications

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- f. Bonding/grounding bar meets all requirements for bonding and grounding of service wires and cable sheaths
 - g. Lockable Cover
 - h. Provide all necessary brackets to mount cross connect modules
- 4. Hinged door in front cover with flush latch and concealed hinge.
 - 5. Key latch to match panelboards.
 - 6. Metal barriers to separate wiring of different systems and voltage.
 - 7. Accessory feet where required for freestanding equipment.

2.6 HANDHOLES AND BOXES

- A. Description: Molded of fiberglass-reinforced polyester resin, with frame and covers.
- B. 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. Armorcast Products Company.
 - 2. Carson Industries LLC.
 - 3. NewBasis.
 - 4. Nordic Fiberglass, Inc.
 - 5. Oldcastle Precast, Inc; Christy Concrete Products.
 - 6. Quazite: Hubbell Power System, Inc; Hubbell Power Systems.
 - 7. Synertech Moulded Products.
 - 8. Owner or Consultant approved equal.
- C. General Requirements for Fiberglass Handholes and Boxes:
 - 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-C.
- D. Configuration: Designed for flush burial with open; closed; or integral closed bottom unless otherwise indicated.
- E. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
- F. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
- G. Cover Legend: Molded lettering, "COMMUNICATIONS".

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- H. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
- I. Handholes 12 Inches Wide by 24 Inches Long (300 mm Wide by 600 mm Long) and Larger: Have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.7 SOURCE QUALITY CONTROL FOR UNDERGROUND ENCLOSURES

- A. Handhole and Pull-Box Prototype Test: Test prototypes of handholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.
 - 1. Tests of materials shall be performed by an independent testing agency.
 - 2. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
 - 3. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

PART 3 EXECUTION

3.1 PATHWAY APPLICATION

- A. Outdoors: Apply pathway products as specified below unless otherwise indicated:
 - 1. Exposed Conduit: GRC; IMC; RNC, Type EPC-40-PVC; RNC, Type EPC-80-PVC.
 - 2. Concealed Conduit, Aboveground: GRC; IMC; EMT; RNC, Type EPC-40-PVC.
 - 3. Underground Conduit: RNC, Type EPC-40-PVC; Type EPC-80-PVC, direct buried or concrete encased.
 - 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 or RNC.
 - 2. Exposed, Not Subject to Severe Physical Damage: EMT or RNC identified for such use].
 - 3. Exposed and Subject to Severe Physical Damage: GRC or IMC. Pathway locations include the following:
 - a. Loading dock.
 - b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
 - c. Mechanical rooms.
 - d. Gymnasiums
 - 4. Concealed in Ceilings and Interior Walls and Partitions: EMT
 - 5. Damp or Wet Locations: GRC or IMC.

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6. Pathways for Optical-Fiber or Communications Cable in Spaces Used for Environmental Air: Plenum-type, communications-cable pathway or EMT.
 7. Pathways for Optical-Fiber or Communications-Cable Risers in Vertical Shafts: Riser-type, communications-cable pathway or EMT.
 8. Pathways for Concealed General-Purpose Distribution of Optical-Fiber or Communications Cable: Riser-type, communications-cable pathway; Plenum-type, communications-cable pathway; EMT.
 9. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel units in institutional and commercial kitchens and damp or wet locations.
- C. Minimum Pathway Size: 3/4-inch (21-mm) trade size for copper and aluminum cables, and 1 inch (25 mm) for optical-fiber cables.
- D. Pathway Fittings: Compatible with pathways and suitable for use and location.
1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
 2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
 3. EMT: Use set-screw or compression, steel or cast-metal 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).

3.2 INSTALLATION

- A. Comply with the following standards for installation requirements except where requirements on Drawings or in this Section are stricter:
1. NECA 1.
 2. NECA/BICSI 568.
 3. TIA-569-C.
 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.

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- 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 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.
- E. Comply with requirements in Section 270544 "Sleeves and Sleeve Seals for Communications Pathways and Cabling" for sleeves and sleeve seals for communications.
- F. Keep pathways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal pathway runs above water and steam piping.
- G. Complete pathway installation before starting conductor installation.
- H. Arrange stub-ups so curved portions of bends are not visible above finished slab.
- I. Install no more than the equivalent of two 90-degree bends in any pathway run. Support within 12 inches (300 mm) 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 (300 mm) of enclosures to which attached.
- L. Pathways Embedded in Slabs:
 - 1. Run conduit larger than 1-inch (27-mm) trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure pathways to reinforcement at maximum 10-foot (3-m) intervals.
 - 2. Arrange pathways to cross building expansion joints at right angles with expansion fittings. Comply with requirements for expansion joints specified in this article.
 - 3. Arrange pathways to keep a minimum of 2 inches (50 mm) of concrete cover in all directions.
 - 4. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.
 - 5. Change from nonmetallic conduit and fittings to GRC or IMC and fittings before rising above floor.
- M. Stub-ups to Above Recessed Ceilings:
 - 1. Use EMT, IMC, or RMC 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.

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- 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 (50-mm) 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 (300 mm) of slack at each end of pull wire. Secure pull wire, so it cannot fall into conduit. Cap pathways designated as spare alongside pathways in use.
- U. Surface Pathways:
 - 1. Install surface pathway for surface telecommunications outlet boxes only where indicated on Drawings.
 - 2. Install surface pathway with a minimum 2-inch (50-mm) radius control at bend points.
 - 3. Secure surface pathway with screws or other anchor-type devices at intervals not exceeding 48 inches (1200 mm) and with no less than two supports per straight pathway section. Support surface pathway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.
- V. Pathways for Optical-Fiber and Communications Cable: Install pathways, metal and nonmetallic, rigid and flexible, as follows:
 - 1. 3/4-Inch (21-mm) Trade Size and Smaller: Install pathways in maximum lengths of 50 feet (15 m).
 - 2. 1-Inch (25-mm) Trade Size and Larger: Install pathways in maximum lengths of 75 feet (23 m).
 - 3. Install with a maximum of two 90-degree bends or equivalent for each length of pathway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.
- W. 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.
- X. 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.

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2. Where an underground service pathway enters a building or structure.
 3. Where otherwise required by NFPA 70.
- Y. Comply with manufacturer's written instructions for solvent welding PVC conduit 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 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.
- AA. Hooks:
1. Size to allow a minimum of 25 percent future capacity without exceeding design capacity limits.
 2. Shall be supported by dedicated support wires. Do not use ceiling grid support wire or support rods.
 3. Hook spacing shall allow no more than 6 inches (150 mm) of slack. The lowest point of the cables shall be no less than 6 inches (150 mm) adjacent to ceilings, mechanical ductwork and fittings, luminaires, power conduits, power and telecommunications outlets, and other electrical and communications equipment.
 4. Space hooks no more than 4 feet (1.2 m) o.c.
 5. Provide a hook at each change in direction.

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- 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 surface 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. 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.
- FF. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.
- GG. Set metal floor boxes level and flush with finished floor surface.
- HH. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.3 INSTALLATION OF UNDERGROUND CONDUIT

- A. Direct-Buried Conduit:
 - 1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Division 31 for pipe of less than 6 inches (150 mm) in nominal diameter.
 - 2. Install backfill as specified in Section 312000 "Earth Moving."
 - 3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches (300 mm) of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Section 312000 "Earth Moving."
 - 4. Install manufactured 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 around conduit 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.

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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 Communications Systems."

3.4 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, 24" below grade.
- E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in enclosure.
- F. Field cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

3.5 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR COMMUNICATIONS PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 270544 "Sleeves and Sleeve Seals for Communications Pathways and Cabling."

3.6 FIRESTOPPING

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

3.7 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

SECTION 27 0536 - CABLE TRAYS FOR COMMUNICATIONS SYSTEMS

PART 1 GENERAL

1.1 SUMMARY

- A. Refer to Technology responsibility matrix, located on plan set for further information.
- B. Section Includes: Contractor is responsible for providing and installing a complete Cable tray system that meets or exceeds the specifications listed below.
 - 1. Ladder cable trays. (Inside the ER and TR's)
 - 2. Wire-basket cable trays. (Outside the ER and TR's)
- C. Related Requirements:
 - 1. Section 26 0536 "Cable Trays for Electrical Systems" for cable trays and accessories serving electrical systems.
 - 2. State of NM DoIT – Standard for Building and Campus Distribution Systems

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: For each type of cable tray.
- 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 and 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.

1.3 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Certificates: For cable trays, accessories, and components, from manufacturer.
- B. Field quality-control reports.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

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1. Layout Responsibility: Preparation of Shop Drawings and Cabling Administration Drawings, Cabling Administration Drawings, and field testing program development by an RCDD.
 2. Installation Supervision: Installation shall be under the direct supervision of Registered Technician, or Level 2 Installer, who shall be present at all times when Work of this Section is performed at Project site.
 3. Testing Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.
- B. Testing Agency Qualifications: An NRTL.
1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

1.5 QUALIFICATIONS

- A. Communications Cabling: The Contractor shall have (5) five years of documented experience performing cable placement, splicing, termination, connecting, and testing for each of the media types and (3) three years of applicable experience with the proposed system manufacturer. In the case of newer technologies that do not have a (3) three year history, the Contractor shall have documented experience for at least half of the lifetime of the new technology. The approved contractor shall, at a minimum, maintain a ratio of one manufacturer or BICSI certified installer for every two non-certified installers assigned to the project.
- B. The contractor shall have on staff a BICSI Certified RCDD as a permanent employee. This staff member shall have been on staff for a minimum of (1) one year prior to the date of this projects release for bid.
- C. The contractor shall have on staff at least (1) one BICSI Certified Technician and this staff member shall have been a full time employee for no less than (1) one year prior to the date of this projects release for bid. A BICSI Certified Technician shall be employed as the on-site Field Supervisor for this project.
- D. The contractor shall provide resumes for the Project Manager, Supervisors and any skilled technicians or installers. Each resume shall include applicable certification documents provided by the manufacturer or BICSI.
1. Project Manager, Supervisors, and Principal Skilled Technicians: minimum of (5) five years' experience in like work.
 2. Category 6 Unshielded Twisted Pair and Fiber Optic Cable Technicians: documented training, licensing, and/or certification for the types of media specified, as applicable as well as certification from the manufacturer of the solution chosen by the owner.

1.6 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer, qualified layout technician, installation supervisor, field inspector and company. The contractor shall provide resumes for the Project Manager, Supervisors and any skilled technicians or installers. Each resume shall include applicable certification documents provided by the manufacturer or BICSI.

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1. Project Manager, installation supervisor, and Principal Skilled Technicians: As a minimum be required to have no less than (5) five years' experience in like work.
 2. The Company/Contractor proposing shall provide historical data confirming the company has a minimum of (5) five years applicable experience.
 3. The Company/Contractor shall have a minimum of (3) three projects of similar size and type within the last (2) years. References for all submitted projects are required to assist with the evaluation.
- B. Category 6 Unshielded Twisted Pair and Fiber Optic Cable Technicians: Documented training, licensing, and/or certification for the types of media specified, as applicable as well as certification from the manufacturer of the solution chosen by the owner.
- C. Source quality-control reports.
- D. Field quality-control reports.

PART 2 PRODUCTS

2.1 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. Component Importance Factor: 1.5, 1.0.

2.2 GENERAL REQUIREMENTS FOR CABLE TRAYS

- A. Cable Trays and Accessories: Identified as defined in NFPA 70 and marked for intended location, application, and grounding.
- B. Sizes and Configurations: See the Cable Tray Schedule on Drawings for specific requirements for types, materials, sizes, and configurations. Cable tray shall be installed with a 40% fill capacity after installation is complete.
- C. Structural Performance: See articles on individual cable tray types for specific values for uniform load distribution, concentrated load, and load and safety factor parameters.

2.3 LADDER CABLE TRAYS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
1. CPI
 2. RXL
 3. B-LINE BY EATON

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4. HUBBEL
5. LEGRAND

B. Description:

1. Configuration: Two I-beam side rails with transverse rungs welded to side rails.
2. Rung Spacing: 12 inches, (300 mm), no greater than 12", o.c.
3. Radius-Fitting Rung Spacing: 9 inches, (225 mm), at center of tray's width.
4. Minimum Cable-Bearing Surface for Rungs: 7/8-inch, (22-mm), width with radius edges.
5. No portion of the rungs shall protrude below the bottom plane of side rails.
6. Structural Performance of Each Rung: 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.
7. Load capacity: 132 lb/ft with support every 5', (200 kg/m with support every 1.5 m). Straight Section Lengths: 10 feet, (3 m), 12 feet, (3.6 m), except where shorter lengths are required to facilitate tray assembly.
8. Width: 12 inches, (300 mm), 18 inches, (457.2mm), unless otherwise indicated on Drawings.
9. Fitting Minimum Radius: 24 inches, (600 mm), 36 inches (900 mm), 48 inches, (1200 mm), dependent on cable tray sized used
10. Class Designation: Comply with NEMA VE 1, Class 12B, Class 12C, Class 20B, and Class 20C..
11. Splicing Assemblies: Bolted type using serrated flange locknuts.
12. Hardware and Fasteners: ASTM F 593 and ASTM F 594 stainless steel, Type 316 Steel, zinc plated according to ASTM B 633.
13. Splice Plate Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.

2.4 WIRE-BASKET CABLE TRAYS

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

1. CPI
2. Homaco
3. B-Line
4. Cablofil Inc.
5. RXL
6. Hubbel
7. Legrand

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B. Description:

1. Configuration: Wires are formed into a standard 2-by-4-inch, (50-by-100-mm), wire mesh pattern with intersecting wires welded together. Mesh sections must have at least one bottom longitudinal wire along entire length of section.
2. Materials: High-strength-steel longitudinal wires with no bends.
3. Safety Provisions: Wire ends along wire-basket sides, (flanges), rounded during manufacturing to maintain integrity of cables and installer safety.
4. Sizes: (Unless noted on plans), (sizing shall be 40% fill capacity at completion of installation):
 - a. Straight sections shall be furnished in standard 118-inch, (3000-mm), lengths.
 - b. Wire-Basket Depth: 4-inch, (100-mm), usable loading depth by, (200 mm), 12 inches, (300 mm), 18 inches, (457.2mm), wide, unless otherwise indicated on Drawings.
5. Connector Assemblies: Bolt welded to plate shaped to fit around adjoining tray wires and mating plate. Mechanically joins adjacent tray wires to splice sections together or to create horizontal fittings.
6. Connector Assembly Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.
7. Hardware and Fasteners: ASTM F 593 and ASTM F 594 stainless steel, Type 316, Steel, zinc plated according to ASTM B 633.

2.5 MATERIALS AND FINISHES

A. Steel:

1. Straight Section and Fitting Side Rails and Rungs: Steel complies with the minimum mechanical properties of ASTM A 1011/A 1011M, SS, Grade 33, ASTM A 1008/A 1008M, Grade 33, Type 2.
2. Steel Tray Splice Plates: ASTM A 1011/A 1011M, HSLAS, Grade 50, Class 1.
3. Fasteners: Steel complies with the minimum mechanical properties of ASTM A 510/A 510M, Grade 1008.
4. Finish: Mill galvanized before fabrication.
 - a. Hardware: Galvanized, ASTM B 633, Chromium-zinc plated, ASTM F 1136.
5. Finish: Electro galvanized before fabrication.
6. Finish: Hot-dip galvanized after fabrication.
 - a. Hardware: Chromium-zinc plated ASTM F 1136, Stainless steel, Type 316, ASTM F 593 and ASTM F 594.
7. Finish: Epoxy-resin, Powder-coat enamel paint.
 - a. Hardware: Chromium-zinc plated ASTM F 1136, Stainless steel, Type 316, ASTM F 593 and ASTM F 594.

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8. Finish: Factory-standard primer, ready for field painting, with chromium-zinc-plated hardware according to ASTM F 1136.
9. Finish: Black oxide finish for support accessories and miscellaneous hardware according to ASTM D 769.

2.6 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.

2.7 WARNING SIGNS

- A. Lettering: 1-1/2-inch, (40-mm-), high, black letters on yellow background with legend "Warning! Not To Be Used as Walkway, Ladder, or Support for Ladders or Personnel."
- B. Comply with requirements for fasteners in Section 260553 "Identification for Electrical Systems."

2.8 SOURCE QUALITY CONTROL

- A. Testing: Test and inspect cable trays according to NEMA VE 1.

PART 3 EXECUTION

3.1 CABLE TRAY INSTALLATION

- A. Install cable trays according to NEMA VE 2.
- 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, and bonding.
- C. Fasten cable tray supports to building structure and install seismic restraints.
- D. Design fasteners and supports to carry cable tray, the cables and a concentrated load of 200 lb., (90 kg). Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems." Comply with seismic-restraint details according to Section 260548, "Vibration and Seismic Controls for Electrical Systems."
- E. Support wire-basket cable trays with, trapeze hangers, and/or wall brackets. Center support will not be accepted.

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- F. Support: trapeze hangers for wire-basket trays with 1/4-inch, (6-mm), 3/8-inch, (10-mm-), diameter rods.
- G. 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.
- H. Install expansion connectors where cable trays cross building expansion joints and in cable tray runs that exceed dimensions recommended in NEMA FG 1, NEMA VE 2. Space connectors and set gaps according to applicable standard.
- I. Seal penetrations through fire and smoke barriers. Comply with requirements in Division 07.
- J. Install capped metal sleeves for future cables through firestop-sealed cable tray penetrations of fire and smoke barriers.
- K. 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.
- L. Install permanent covers, if used, after installing cable. Install cover clamps according to NEMA VE 2.
- M. Install warning signs in visible locations on or near cable trays after cable tray installation.

3.2 CABLE TRAY GROUNDING

- A. Ground cable trays according to NFPA 70 unless additional grounding is specified. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Cable trays with communications cable shall be bonded together with splice plates listed for grounding purposes or with listed bonding jumpers.
- C. Cable trays with control conductors shall be bonded together with splice plates listed for grounding purposes or with listed bonding jumpers.
- D. 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."

3.3 CABLE INSTALLATION

- A. Install cables only when each cable tray run has been completed and inspected.
- B. Fasten cables on horizontal runs with Velcro; tie wraps shall **not** be used. Fasten cables on vertical runs to cable trays every 18 inches (450 mm).
- C. 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 60 inches (1524 mm).

- D. Tie MI cables down every 36 inches (900 mm) where required to provide a 2-hour fire rating and every 72 inches (1800 mm) elsewhere.

3.4 CONNECTIONS

- A. Connect raceways to cable trays according to requirements in NEMA VE 2.

3.5 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 re-torque in suspect areas.
 7. Check for missing, incorrect, or damaged bolts, bolt heads, or nuts. When found, replace with specified hardware.
 8. 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.

3.6 PROTECTION

- A. Protect installed cable trays and cables.

END OF SECTION

**SECTION 27 0544 - SLEEVES & SLEEVE SEALS FOR COMMUNICATIONS PATHWAYS &
CABLING**

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. State of NM DoIT – Standard for Building and Campus Distribution Systems

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. 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 QUALITY ASSURANCE

- A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff. (submit qualifications)
 - 1. Layout Responsibility: Preparation of Shop Drawings and Cabling Administration Drawings, Cabling Administration Drawings and field testing program development by an RCDD.
 - 2. Installation Supervision: Installation shall be under the direct supervision of a Registered Technician, or Level 2 Installer, who shall be present at all times when Work of this Section is performed at Project site.
 - 3. Testing Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.
- B. Testing Agency Qualifications: An NRTL.
 - 1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

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- C. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - 1. Flame-Spread Index: 25 or less.
 - 2. Smoke-Developed Index: 50 or less.
- 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. Telecommunications Pathways and Spaces: Comply with TIA/EIA-569-C.
- F. Grounding: Comply with TIA-607-B.

1.4 QUALIFICATIONS

- A. Communications Cabling: The Contractor shall have (5) five years of documented experience performing cable placement, splicing, termination, connecting, and testing for each of the media types and (3) three years of applicable experience with the proposed system manufacturer. In the case of newer technologies that do not have a (3) three year history, the Contractor shall have documented experience for at least half of the lifetime of the new technology. The approved contractor shall, at a minimum, maintain a ratio of one manufacturer or BICSI certified installer for every two non-certified installers assigned to the project.
- B. The contractor shall have on staff a BICSI Certified RCDD as a permanent employee. This staff member shall have been on staff for a minimum of (1) one year prior to the date of this projects release for bid.
- C. The contractor shall have on staff at least (1) one BICSI Certified Technician and this staff member shall have been a full time employee for no less than (1) one year prior to the date of this projects release for bid. A BICSI Certified Technician shall be employed as the on-site Field Supervisor for this project.
- D. The contractor shall provide resumes for the Project Manager, Supervisors and any skilled technicians or installers. Each resume shall include applicable certification documents provided by the manufacturer or BICSI.
 - 1. Project Manager, Supervisors, and Principal Skilled Technicians: minimum of (5) five years' experience in like work.
 - 2. Category 6 Unshielded Twisted Pair and Fiber Optic Cable Technicians: documented training, licensing, and/or certification for the types of media specified, as applicable as well as certification from the manufacturer of the solution chosen by the owner.

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Sustainable Design Submittals:

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1. Product Data for Credit EQ 4.1: For sealants, documentation including printed statement of VOC content.
2. Laboratory Test Reports for Credit EQ 4: For sealants, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

PART 2 PRODUCTS

2.1 SLEEVES

- A. Wall Sleeves:
 1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.
 2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.
- B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch (0.6-mm) 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 (1270 mm) and with no side larger than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
 - b. For sleeve cross-section rectangle perimeter 50 inches (1270 mm) or more and one or more sides larger than 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

2.2 SLEEVE-SEAL SYSTEMS

- A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and pathway or cable.
- B. Utilize Intumescent Pillows for backbone conduits that span floors.

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1. Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Advance Products & Systems, Inc.
 - b. CALPICO, Inc.
 - c. Metraflex Company (The).
 - d. Pipeline Seal and Insulator, Inc.
 - e. Proco Products, Inc.
 - f. Owner or Consultant approved equal.
2. Sealing Elements: EPDM or Nitrile (Buna N) rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
3. Pressure Plates: Carbon steel; Plastic; or Stainless steel.
4. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating; or Stainless steel of length required to secure pressure plates to sealing elements.

2.3 SLEEVE-SEAL FITTINGS

- A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber waterstop collar with center opening to match piping OD.
 1. Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Presealed Systems.
 - b. Owner or Consultant approved equal.

2.4 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.
 2. Sealant shall have VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 3. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

PART 3 EXECUTION

3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

- A. Comply with NECA 1.
- B. Comply with NEMA VE 2 for cable tray and cable penetrations.
- C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:
 - 1. Interior Penetrations of Non-Fire-Rated Walls and Floors:
 - a. Seal annular space between sleeve and 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 (6.4-mm) annular clear space between sleeve and pathway or cable unless sleeve seal is to be installed.
 - 4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
 - 5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches (50 mm) 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 or cast-iron pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) 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 (25-mm) annular clear space between pathway or cable and sleeve for installing sleeve-seal system.

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at 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.

3.3 SLEEVE-SEAL-FITTING INSTALLATION

- A. Install sleeve-seal fittings in new walls and slabs as they are constructed.
- B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.
- C. Secure nailing flanges to concrete forms.
- D. Using grout, seal the space around outside of sleeve-seal fittings.

END OF SECTION

SECTION 27 1100 - COMMUNICATIONS EQUIPMENT ROOM FITTINGS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Contractor is responsible for providing and installing Data cabinet/racks and equipment room fittings shown on plans and listed below, that meets or exceeds the specifications listed below.

1.2 SUMMARY

- A. Section Includes:
 - 1. Telecommunications mounting elements.
 - 2. Backboards.
 - 3. Telecommunications equipment racks and cabinets.
 - 4. Grounding.
- B. Related Requirements:
 - 1. Section 27 1300 "Communications Backbone Cabling" for voice and data cabling associated with system panels and devices.
 - 2. Section 27 1500 "Communications Horizontal Cabling" for voice and data cabling associated with system panels and devices.

1.3 DEFINITIONS

- A. BICSI: Building Industry Consulting Service International.
- B. LAN: Local area network.
- C. RCDD: Registered Communications Distribution Designer.

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.

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- 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 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 the direct supervision of RCDD, RCDD/NTS, Commercial Installer, and Level 2 installer.
 - 2. Installation Supervision: Installation shall be under the direct supervision of Registered Technician, or, Level 2 Installer, who shall be present at **all** times when Work of this Section is performed at Project site.
 - 3. Field Inspector: Currently registered by BICSI as RCDD, Commercial Installer Level 2, to perform the on-site inspection.

1.6 QUALIFICATIONS

- A. Communications Cabling: The Contractor shall have (5) five years of documented experience performing cable placement, splicing, termination, connecting, and testing for each of the media types and (3) three years of applicable experience with the proposed system manufacturer. In the case of newer technologies that do not have a (3) three year history, the Contractor shall have documented experience for at least half of the lifetime of the new technology. The approved contractor shall, at a minimum, maintain a ratio of one manufacturer or BICSI certified installer for every two non-certified installers assigned to the project.
- B. The contractor shall have on staff a BICSI Certified RCDD as a permanent employee. This staff member shall have been on staff for a minimum of (1) one year prior to the date of this projects release for bid.
- C. The contractor shall have on staff at least (1) one BICSI Certified Technician and this staff member shall have been a full time employee for no less than (1) one year prior to the date of this projects release for bid. A BICSI Certified Technician shall be employed as the on-site Field Supervisor for this project.
- D. The contractor shall provide resumes for the Project Manager, Supervisors and any skilled technicians or installers. Each resume shall include applicable certification documents provided by the manufacturer or BICSI.
 - 1. Project Manager, Supervisors, and Principal Skilled Technicians: minimum of (5) five years' experience in like work.

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2. Category 6 Unshielded Twisted Pair and Fiber Optic Cable Technicians: documented training, licensing, and/or certification for the types of media specified, as applicable as well as certification from the manufacturer of the solution chosen by the owner.

1.7 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer, qualified layout technician, installation supervisor, field inspector and company. The contractor shall provide resumes for the Project Manager, Supervisors and any skilled technicians or installers. Each resume shall include applicable certification documents provided by the manufacturer or BICSI.
 1. Project Manager, installation supervisor, and Principal Skilled Technicians: As a minimum be required to have no less than (5) five years' experience in like work.
 2. The Company/Contractor proposing shall provide historical data confirming the company has a minimum of (5) five years applicable experience.
 3. The Company/Contractor shall have a minimum of (3) three projects of similar size and type within the last (2) years. References for all submitted projects are required to assist with the evaluation.
- B. Category 6 Unshielded Twisted Pair and Fiber Optic Cable Technicians: Documented training, licensing, and/or certification for the types of media specified, as applicable as well as certification from the manufacturer of the solution chosen by the owner.
- C. Source quality-control reports.
- D. Field quality-control reports.
- E. Seismic Qualification Certificates: For equipment frames 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.

PART 2 PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Equipment frames shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.2 BACKBOARDS

- A. Backboards: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches, (19 by 1220 by 2440 mm). Comply with requirements for plywood backing panels specified in Section 06 1000 "Rough Carpentry." Use fire rated plywood. Paint all sides with two coats of white fire retardant paint. Do not paint over plywood rating stamp.

2.3 EQUIPMENT FRAMES

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. Chatsworth Products
 - 2. Substitutions: Owner and Consultant approved equal
- B. General Frame Requirements:
 - 1. Distribution Frames: Freestanding and wall-mounting, modular-steel units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.
 - 2. Module Dimension: Width compatible with EIA 310-D standard, 19-inch (480-mm) panel mounting.
 - 3. Height: 108"
 - 4. Rack Units: 58 RU
 - 5. Finish: Manufacturer's standard, baked-polyester powder coat.
- C. Floor-Mounted Racks: Modular-type, steel or aluminum construction.
 - 1. Vertical and horizontal cable management channels, top and bottom cable troughs, grounding lug and a power strip.
 - 2. Baked-polyester powder coat finish.
 - 3. Enclosed, 2 or 4 post configuration as per plans.
- D. Modular Freestanding Cabinets:
 - 1. Removable and lockable side panels.
 - 2. Hinged and lockable front and rear doors.
 - 3. Adjustable feet for leveling.
 - 4. Screened ventilation openings in the roof and rear door.
 - 5. Cable access provisions in the roof and base.
 - 6. Grounding bus bar.
 - 7. Rack, or Roof-mounted, 550-cfm (260-L/s) fan with filter.
 - 8. Power strip.
 - 9. Baked-polyester powder coat finish.
 - 10. All cabinets keyed alike.

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- E. Modular Wall Cabinets:
 - 1. Wall mounting.
 - 2. Steel, Aluminum Steel or aluminum construction.
 - 3. Treated to resist corrosion.
 - 4. Lockable front and rear doors.
 - 5. Louvered side panels.
 - 6. Cable access provisions top and bottom.
 - 7. Grounding lug.
 - 8. Rack, Roof-mounted, 250-cfm (118-L/s) fan.
 - 9. Power strip.
 - 10. All cabinets keyed alike.

- F. Cable Management for Equipment Frames:
 - 1. Integral wire retaining fingers.
 - 2. Baked-polyester powder coat finish.
 - 3. Vertical cable management panels shall have front and rear channels, with covers.
 - 4. Provide horizontal crossover cable manager at the top of each relay rack, with a minimum height of two rack units each.

2.4 POWER STRIPS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. Chatsworth Products, Inc.

- B. Power Strips: Comply with UL 1363.
 - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 2. Rack mounting.
 - 3. Power monitored
 - 4. Coordinate with Owner's IT Group (NM DoIT) for plug configuration.
 - 5. LED indicator lights for power and protection status.
 - 6. LED indicator lights for reverse polarity and open outlet ground.
 - 7. Circuit Breaker and Thermal Fusing: When protection is lost, circuit opens and cannot be reset.
 - 8. Circuit Breaker and Thermal Fusing: Unit continues to supply power if protection is lost.
 - 9. Rocker-type on-off switch, illuminated when in on position.
 - 10. Peak Single-Impulse Surge Current Rating: 33 kA per phase.

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11. Protection modes shall be line to neutral, line to ground, and neutral to ground. UL 1449 clamping voltage for all three modes shall be not more than 330 V.

2.5 GROUNDING

- A. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems" for grounding conductors and connectors.
- B. Telecommunications Main Bus Bar:
 1. Connectors: Mechanical type, cast silicon bronze, solderless, compression exothermic-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.
 2. Ground Bus Bar: Copper, minimum 1/4 inch thick by 4 inches wide, (6 mm thick by 100 mm wide), with 9/32-inch, (7.14-mm), holes spaced 1-1/8 inches, (28 mm), apart.
 3. Stand-Off Insulators: Comply with UL 891 for use in switchboards, 600 V. Lexan or PVC, impulse tested at 5000 V.
- C. Comply with J-STD-607-A.

2.6 LABELING

- A. Comply with TIA/EIA-606-A and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

PART 3 EXECUTION

3.1 ENTRANCE FACILITIES

- A. Contact telecommunications service provider and arrange for installation of demarcation point, protected entrance terminals, and an enclosed 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, buried and aerial pathways.

3.2 INSTALLATION

- A. Comply with NECA 1.
- B. Comply with BICSI TDMM for layout and installation of communications equipment rooms.
- C. Bundle, lace, and train conductors and cables to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.
- D. Coordinate layout and installation of communications equipment with Owner's telecommunications and LAN equipment and service suppliers. Coordinate service entrance arrangement with local exchange carrier.

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1. Meet jointly with telecommunications and LAN equipment suppliers, local exchange carrier representatives, and Owner to exchange information and agree on details of equipment arrangements and installation interfaces.
 2. Record agreements reached in meetings and distribute them to other participants.
 3. Adjust arrangements and locations of distribution frames, cross-connects, and patch panels in equipment rooms to accommodate and optimize arrangement and space requirements of telephone switch and LAN equipment.
 4. Adjust arrangements 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 the equipment room.
- E. Coordinate location of power raceways and receptacles with locations of communications equipment requiring electrical power to operate.

3.3 SLEEVE AND SLEEVE SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 27 0544 "Sleeves and Sleeve Seals for Communications Pathways and Cabling."

3.4 FIRESTOPPING

- A. Comply with requirements in Section 078413 "Penetration Firestopping."
- B. Comply with TIA-569-B; Annex A, "Firestopping."
- C. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.5 GROUNDING

- A. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.
- B. Comply with J-STD-607-A.
- C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch (50-mm) clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.
- D. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.
1. Bond the shield of shielded cable to the grounding bus bar in communications rooms and spaces.

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3.6 IDENTIFICATION

- A. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements in Section 26 0553 "Identification for Electrical Systems."
- B. Comply with requirements in Section 09 9123 "Interior Painting" for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.
- C. Paint and label colors for equipment identification shall comply with TIA/EIA-606-A for all Class 4 level of administration, including optional identification requirements of this standard.
- D. Labels shall be preprinted or computer-printed type.

END OF SECTION

SECTION 27 1500 - COMMUNICATIONS HORIZONTAL CABLING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. State of NM DoIT – Standard for Building and Campus Distribution Systems

1.2 SUMMARY

- A. Section Includes:
 - 1. UTP cabling.
 - 2. Multiuser telecommunications outlet assemblies.
 - 3. Cable connecting hardware, patch panels, and cross-connects.
 - 4. Telecommunications outlet/connectors.
 - 5. Cabling system identification products.
 - 6. Cable management system.
 - 7. Warranty
- B. Related Requirements:
 - 1. Section 27 1300 "Communications Backbone Cabling" for voice and data cabling associated with system panels and devices.

1.3 DEFINITIONS

- A. BICSI: Building Industry Consulting Service International.
- B. Consolidation Point: A location for interconnection between horizontal cables extending from building pathways and horizontal cables extending into furniture pathways.
- C. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.
- D. EMI: Electromagnetic interference.
- E. IDC: Insulation displacement connector.
- F. LAN: Local area network.

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- G. MUTOA: Multiuser telecommunications outlet assembly, a grouping in one location of several telecommunications outlet/connectors.
- H. Outlet/Connectors: A connecting device in the work area on which horizontal cable or outlet cable terminates.
- I. RCDD: Registered Communications Distribution Designer.
- J. UTP: Unshielded twisted pair.

1.4 ADMINISTRATIVE REQUIREMENTS

- A. Coordinate layout and installation of telecommunications cabling with Owner's telecommunications and LAN equipment and service suppliers.
- B. Coordinate telecommunications outlet/connector locations with location of power receptacles at each work area.

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. For coaxial cable, include the following installation data for each type used:
 - a. Nominal OD.
 - b. Minimum bending radius.
 - c. Maximum pulling tension.
- B. Shop Drawings:
 - 1. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
 - 2. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
 - 3. Cabling administration drawings and printouts.
 - 4. Wiring diagrams to show typical wiring schematics, including the following:
 - a. Cross-connects.
 - b. Patch panels.
 - c. Patch cords.
 - 5. Cross-connects and patch panels. Detail mounting assemblies, and show elevations and physical relationship between the installed components.

1.6 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer, qualified layout technician, installation supervisor, and field inspector.

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- B. Source quality-control reports.
- C. Field quality-control reports.

1.7 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For splices and connectors to include in maintenance manuals.
- 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.

1.8 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Patch-Panel Units: One of each type.
 - 2. Connecting Blocks: One of each type.
 - 3. Device Plates: One of each type.
 - 4. Multiuser Telecommunications Outlet Assemblies: One of each type.

1.9 QUALITY ASSURANCE

- A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff. (submit qualifications)
 - 1. Layout Responsibility: Preparation of Shop Drawings and Cabling Administration Drawings, Cabling Administration Drawings and field testing program development by an RCDD.
 - 2. Installation Supervision: Installation shall be under the direct supervision of a Registered Technician, or Level 2 Installer, who shall be present at all times when Work of this Section is performed at Project site.
 - 3. Testing Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.
- B. Testing Agency Qualifications: An NRTL.
 - 1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

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- C. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - 1. Flame-Spread Index: 25 or less.
 - 2. Smoke-Developed Index: 50 or less.
- 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. Telecommunications Pathways and Spaces: Comply with TIA-569-C.
- F. Grounding: Comply with TIA-607-B.
- G. Low-voltage Contractor shall coordinate with Electrical Contractor on pathway installation to ensure Category Cable lengths to not exceed maximum length as defined by TIA and Manufacturer.

1.10 QUALIFICATIONS

- A. Communications Cabling: The Contractor shall have (5) five years of documented experience performing cable placement, splicing, termination, connecting, and testing for each of the media types and (3) three years of applicable experience with the proposed system manufacturer. In the case of newer technologies that do not have a (3) three year history, the Contractor shall have documented experience for at least half of the lifetime of the new technology. The approved contractor shall, at a minimum, maintain a ratio of one manufacturer or BICSI certified installer for every two non-certified installers assigned to the project.
- B. The contractor shall have on staff a BICSI Certified RCDD as a permanent employee. This staff member shall have been on staff for a minimum of (1) one year prior to the date of this projects release for bid.
- C. The contractor shall have on staff at least (1) one BICSI Certified Technician and this staff member shall have been a full time employee for no less than (1) one year prior to the date of this projects release for bid. A BICSI Certified Technician shall be employed as the on-site Field Supervisor for this project.
- D. The contractor shall provide resumes for the Project Manager, Supervisors and any skilled technicians or installers. Each resume shall include applicable certification documents provided by the manufacturer or BICSI.
 - 1. Project Manager, Supervisors, and Principal Skilled Technicians: minimum of (5) five years' experience in like work.
 - 2. Category 6 Unshielded Twisted Pair and Fiber Optic Cable Technicians: documented training, licensing, and/or certification for the types of media specified, as applicable as well as certification from the manufacturer of the solution chosen by the owner.

1.11 DELIVERY, STORAGE, AND HANDLING

- A. Test cables upon receipt at Project site.
 - 1. Test optical fiber cables to determine the continuity of the strand end to end. Use optical fiber flashlight or optical loss test set.
 - 2. Test optical fiber cables while on reels. Use an optical time domain reflectometer to verify the cable length and locate cable defects, splices, and connector; including the loss value of each. Retain test data and include the record in maintenance data.
 - 3. Test each pair of UTP cable for open and short circuits.

1.12 COORDINATION

- A. Before the start of any State wiring project the contractor must coordinate all work with the Infrastructure Voice Radio Division DOIT Engineer, the agency project manager, and the General Contractor. All three entities must agree on the plan of procedure and any changes in the process shall be made in writing to the Infrastructure Voice Radio Division. The wiring of the building is to be started before the ceiling tile is installed, and after the following are completed:
 - 1. The pathway installation to the workstation area.
 - 2. The ceiling grid is installed.
 - 3. The Main Communications Equipment Room and/or Telecommunications Room are completed.
- B. The wiring contractor must coordinate all activities with the General Contractor and Infrastructure Voice Radio Division or agency project leader. The wiring is to be completed prior to the completion date of the building. The General Contractor, in turn, must coordinate with the local telephone company for details relating to the building's entrance cabling and conduits. Agencies will initiate all telephone, voice, and shared (i.e. voice and data) project coordination through the DOIT automated work order system. The Infrastructure Voice Radio Division and Agency may, by mutual agreement, modify, waive, or adjust any specifications in this document, so long as such modifications, waiver, or adjustment does not conflict with local and national codes and industry standards
- C. Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications and LAN equipment and service suppliers.

PART 2 PRODUCTS

2.1 HORIZONTAL CABLING DESCRIPTION

- A. Horizontal cable and its connecting hardware provide the means of transporting signals between the telecommunications outlet/connector and the horizontal cross-connect located in the

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communications equipment room. This cabling and its connecting hardware are called a "permanent link," a term that is used in the testing protocols.

1. TIA-568-C.1 requires that a minimum of two telecommunications outlet/connectors be installed for each work area.
 2. Horizontal cabling shall contain no more than one transition point or consolidation point between the horizontal cross-connect and the telecommunications outlet/connector.
 3. Bridged taps and splices shall not be installed in the horizontal cabling.
 4. Splitters shall not be installed as part of the optical fiber cabling.
- B. A work area is approximately 100 sq. ft. (9.3 sq. m), and includes the components that extend from the telecommunications outlet/connectors to the station equipment.
- C. The maximum allowable horizontal cable length is 295 feet (90 m). This maximum allowable length does not include an allowance for the length of 16 feet (4.9 m) to the workstation equipment or in the horizontal cross-connect.

2.2 BACKBOARDS

- A. Backboards: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches, (19 by 1220 by 2440 mm). Comply with requirements for plywood backing panels specified in Section 06 1000 "Rough Carpentry." Use fire rated plywood. Paint all sides with two coats of white fire retardant paint. Do not paint over plywood rating stamp.

2.3 UTP CABLE

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Belden Inc.
 2. Berk-Tek; a Nexans company.
 3. CommScope, Inc.
 4. General Cable
 5. Mohawk; a division of Belden Networking, Inc.
 6. Superior Essex Inc.
 7. SYSTIMAX Solutions; a CommScope, Inc. brand.
 8. Consultant or Owner approved equal.
- B. Description: 100-ohm, four-pair UTP, covered with a blue thermoplastic jacket. Low outside diameter not greater than 0.23 OD(Category 6); 0.25OD(Category 6A); with exception to OSP cable, and Audio/Visual 27-4100 materials.
1. Comply with ICEA S-90-661 for mechanical properties.
 2. Comply with TIA-568-C.1 for performance specifications.
 3. Comply with TIA-568-C.2, Category 6.

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4. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70 for the following types:
 - a. Communications, Plenum Rated: Type CMP or CMP-LP, complying with NFPA 262.
 - b. Communications, OSP Rated, for surveillance applications.
 - 1) OSP cable shall meet or exceed or ANSI/TIA and BICSI requirements.

2.4 UTP CABLE HARDWARE

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. American Technology Systems Industries, Inc.
 2. Belden Inc.
 3. Hubbell Premise Wiring.
 4. Leviton Commercial Networks Division.
 5. Panduit Corp.
 6. Siemon
 7. Tyco Electronics Corporation; AMP Products.
 8. Consultant or Owner approved equal.
- B. General Requirements for Cable Connecting Hardware: Comply with TIA-568-C.2, IDC type, with modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of same category or higher.
- C. Connecting Blocks: 210 -style IDC for Category 6 cabling. Provide blocks for the number of cables terminated on the block. Integral with connector bodies, including plugs and jacks where indicated.
- D. Cross-Connect: Modular array of connecting blocks arranged to terminate building cables and permit interconnection between cables.
 1. Number of Terminals per Field: One for each conductor in assigned cables.
- E. Patch Panel: Modular panels housing multiple-numbered jack units with IDC-type connectors at each jack for permanent termination of pair groups of installed cables.
 1. Number of Jacks per Field: One for each four-pair UTP cable indicated.
- F. Jacks and Jack Assemblies: Modular, color-coded, eight-position modular receptacle units with integral IDC-type terminals. T568A pin out.
 1. All outlet jacks will contain a color indicator and coded as follows:
 - a. Category 6 voice must have a blue icon.
 - b. Category 6 data must have a red icon.
 - c. OSP applications shall be rated for outside plant environments.

2.5 MULTIUSER TELECOMMUNICATIONS OUTLET ASSEMBLY (MUTOA)

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Belden Inc
 2. Chatsworth Products, Inc.
 3. Hubbell Premise Wiring.
 4. Molex Premise Networks; a division of Molex, Inc.
 5. Ortronics, Inc.; a subsidiary of Legrand Group.
 6. Panduit Corp.
 7. Siemon
 8. Consultant or Owner approved equal.
- B. Description: MUTOAs shall meet the requirements for cable connecting hardware.
1. Number of Connectors per Field:
 - a. One for each four-pair UTP cable indicated.
 2. Mounting: Wall; Table.
 3. NRTL listed as complying with UL 50 and UL 1863.
 4. Label shall include maximum length of work area cords, based on TIA-568-C.1.
 5. When installed in plenums used for environmental air, NRTL listed as complying with UL 2043.

2.6 TELECOMMUNICATIONS OUTLET/CONNECTORS

- A. Jacks: 100-ohm, balanced, twisted-pair connector; four-pair, eight-position modular. Comply with TIA-568-C.1.
- B. Workstation Outlets: Four-port-connector assemblies mounted in single or multi-gang faceplate.
1. Plastic Faceplate: High-impact plastic. Coordinate color with Section 262726 "Wiring Devices."
 2. Metal Faceplate: Stainless steel, for labs complying with requirements in Section 26 2726 "Wiring Devices."
 - a. Confirm with owner and architect if stainless steel faceplates are required in Vehicle Inspection Building prior to ordering.
 3. For use with snap-in jacks accommodating any combination of UTP, optical fiber, and coaxial work area cords.
 - a. Flush mounting jacks, positioning the cord at a 45-degree angle.
 4. Legend: Snap-in, clear-label covers and machine-printed paper inserts.

2.7 GROUNDING

- A. Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems" for grounding conductors and connectors.
- B. Comply with TIA-607-B.

2.8 IDENTIFICATION PRODUCTS

- A. Comply with requirements for identification in Section 260553 "Identification for Electrical Systems."
- B. Comply with TIA-606-B and UL 969 for labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

2.9 SOURCE QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to evaluate cables.
- B. Factory test UTP and optical fiber cables on reels according to TIA-568-C.1.
- C. Factory test UTP cables according to TIA-568-C.2.
- D. Factory test multimode optical fiber cables according to TIA-526-14-C and TIA-568-C.3.
- E. Factory-sweep test coaxial cables at frequencies from 5 MHz to 1 GHz. Sweep test shall test the frequency response, or attenuation over frequency, of a cable by generating a voltage whose frequency is varied through the specified frequency range and graphing the results.
- F. Cable will be considered defective if it does not pass tests and inspections.
- G. Prepare test and inspection reports.

PART 3 EXECUTION

3.1 ENTRANCE FACILITIES

- A. Coordinate backbone cabling with the protectors and demarcation point provided by communications service provider.
- B. Coordinate backbone cabling with owner's IT dept.

3.2 WIRING METHODS

- A. Install cables in pathways and cable trays except within consoles, cabinets, desks, and counters, and except in inaccessible ceiling spaces and in gypsum board partitions where

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unenclosed wiring method may be used. Conceal pathways and cables except in unfinished spaces.

1. Install plenum cable in environmental air spaces, including plenum ceilings and access flooring
 2. Install "wet" rated cable when the voice and data cabling conduit pathway is in the slab or underground. Transition "wet" rated cable to plenum if pathway extends into a plenum space without conduit. Wet rated cable shall not be installed in the open plenum ceiling space.
 3. Comply with requirements in Section 27 0528 "Pathways for Communications Systems."
- B. Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
1. Bundle all telecommunications cabling going to each "Zone" consolidation enclosure in a neat and organized manner utilizing Velcro wire wraps.
 2. Provide labeling every 6ft on bundle with "Zone" identification.
- C. Wiring within Enclosures:
1. Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.
 2. Install lacing bars and distribution spools.
 3. Install conductors parallel with or at right angles to sides and back of enclosure.

3.3 INSTALLATION OF CABLES

- A. Comply with NECA 1.
- B. General Requirements for Cabling:
1. Comply with TIA-568-C.1.
 2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
 3. Install 2100-style IDC termination hardware unless otherwise indicated.
 4. MUTOA shall not be used as a cross-connect point.
 5. Consolidation points may be used only for making a direct connection to telecommunications outlet/connectors:
 - a. Do not use consolidation point as a cross-connect point, as a patch connection, or for direct connection to workstation equipment.
 - b. Locate consolidation points for UTP at least 49 feet (15 m) from communications equipment room.
 6. Terminate conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
 7. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.

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8. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
 9. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.
 10. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
 11. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
 12. In the communications equipment room, install a 10-foot- (3-m-) long service loop on each end of cable.
 13. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.
 14. Under no circumstances can horizontal pathways be cable tied, cinched to existing false ceilings or laid upon the ceiling tile.
 15. All cables must be bundled and or supported by Approved Reusable Hook and Loop Cable Ties. Nylon tie wraps are NOT acceptable.
- C. UTP Cable Installation:
1. Comply with TIA-568-C.2, using the T568A pin out scheme.
 2. Do not untwist UTP cables more than 1/2 inch (12 mm) from the point of termination to maintain cable geometry.
- D. Optical Fiber Cable Installation:
1. Comply with TIA-568-C.3.
 2. Cable may be terminated on connecting hardware that is rack or cabinet mounted.
- E. Open-Cable Installation:
1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
 2. Suspend UTP cable not in a wireway or pathway a minimum of 6 inches (152 mm) above ceilings by cable supports not more than 48 inches (1220 mm) apart.
 3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.
- F. Installation of Cable Routed Exposed under Raised Floors:
1. Install plenum-rated cable only.
 2. Install cabling after the flooring system has been installed in raised floor areas.
 3. Coil cable 20 feet (1800 mm) long not less than 12 inches (300 mm) in diameter below each feed point.
- G. Group connecting hardware for cables into separate logical fields.

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- H. Separation from EMI Sources:
1. Comply with BICSI TDMM and TIA-569-C for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
 2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches (300 mm).
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches (610 mm).
 3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches (150 mm).
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches (300 mm).
 4. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches (76 mm).
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches (150 mm).
 5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches (1200 mm).
 6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).
- I. Protect cabling during installation:
1. Protect voice and data cabling cables from any liquid, paints, solvents, debris, or other contaminants, per the manufacturers installation guidelines. Cables shall be replaced if damaged.

3.4 FIRESTOPPING

- A. Comply with requirements in Division 07.

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- B. Comply with TIA-569-C, Annex A, "Firestopping."
- C. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.5 GROUNDING

- A. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.
- B. Comply with TIA-607-B.
- C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch (50-mm) clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.
- D. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.

3.6 IDENTIFICATION

- A. Identify system components, wiring, and cabling complying with TIA-606-B. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
 - 1. Administration Class: Refer to State of NM DoIT – Standard for Building and Campus Distribution Systems for requirements and administration level.
 - 2. Color-code cross-connect fields. Apply colors to voice and data service backboards, connections, covers, and labels.
- B. Using cable management system software specified in Part 2, develop Cabling Administration Drawings for system identification, testing, and management. Use unique, alphanumeric designation for each cable and label cable, jacks, connectors, and terminals to which it connects with same designation. At completion, cable and asset management software shall reflect as-built conditions.
- C. Paint and label colors for equipment identification shall comply with TIA-606-B for Class 4 level of administration, including optional identification requirements of this standard.
- D. Cable Schedule: Post in prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.
- E. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, backbone pathways and cables, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding

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conductors. Follow convention of TIA-606-B. Furnish electronic record of all drawings, in software and format selected by Owner.

F. Cable and Wire Identification:

1. Label each cable within 4 inches (100 mm) of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet (4.5 m).
4. Label each terminal strip and screw terminal in each cabinet, rack, or panel.
 - a. Individually number wiring conductors connected to terminal strips, and identify each cable or wiring group being extended from a panel or cabinet to a building-mounted device shall be identified with name and number of particular device as shown.
 - b. Label each unit and field within distribution racks and frames.
5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.
6. Uniquely identify and label work area cables extending from the MUTOA to the work area. These cables may not exceed the length stated on the MUTOA label.

G. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA-606-B.

1. Cables use flexible vinyl or polyester that flex as cables are bent.

H. Backboard subsections will be color-coded according to function per the following scheme:

1. GREEN = Network connections. Network connections or auxiliary terminations (Ex. cabling from the network interface to the trunk cross connects).
2. PURPLE = Trunk and line connections from system common equipment (Ex. cable connections from a PBX)
3. WHITE = First level backbone and campus cable connections (Ex. the cabling that runs between Main Communications Equipment Rooms and Telecommunication Rooms and the inter-building facilities.)
4. YELLOW = Auxiliary equipment connections (Ex. cabling from a host computer or console device).
5. BLUE = Horizontal wiring to work stations (Ex. the wiring from an IO, typically located in an office, to a cross connect in the Main Communications Equipment Room, a Telecommunication Room, or satellite location).
6. RED = Trunk and line connections from key telephone systems equipment.

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7. GRAY = Second level backbone cable connections (Ex. the wiring that runs between cross connects, especially between a backbone and a satellite Room or between satellite locations.)
8. ORANGE = Demarcation point. Central office terminations.
9. BROWN = Inter-building backbone.

3.7 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections:
 1. Visually inspect UTP and optical fiber cable jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA-568-C.1.
 2. Visually confirm Category 6, marking of outlets, cover plates, outlet/connectors, and patch panels.
 3. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
 4. Test UTP backbone copper cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross-connection.
 - a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
 5. Optical Fiber Cable Tests:
 - a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.1. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
 - b. Link End-to-End Attenuation Tests:
 - 1) Horizontal and multimode backbone link measurements: Test at 850 or 1300 nm in 1 direction according to TIA-526-14-C, Method B, One Reference Jumper.
 - 2) Attenuation test results for backbone links shall be less than 2.0 dB. Attenuation test results shall be less than that calculated according to equation in TIA-568-C.1.

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6. UTP Performance Tests:
 - a. Test for each outlet and MUTOA. Perform the following tests according to TIA-568-C.1 and TIA-568-C.2:
 - 1) Wire map.
 - 2) Length (physical vs. electrical, and length requirements).
 - 3) Insertion loss.
 - 4) Near-end crosstalk (NEXT) loss.
 - 5) Power sum near-end crosstalk (PSNEXT) loss.
 - 6) Equal-level far-end crosstalk (ELFEXT).
 - 7) Power sum equal-level far-end crosstalk (PSELFEXT).
 - 8) Return loss.
 - 9) Propagation delay.
 - 10) Delay skew.
7. Optical Fiber Cable Performance Tests: Perform optical fiber end-to-end link tests according to TIA-568-C.1 and TIA-568-C.3.
8. Coaxial Cable Tests: Conduct tests according to Section 274133 "Master Antenna Television System."
9. Final Verification Tests: Perform verification tests for UTP systems after the complete communications cabling and workstation outlet/connectors are installed.
 - a. Voice Tests: These tests assume that dial tone service has been installed. Connect to the network interface device at the demarcation point. Go off-hook and listen and receive a dial tone. If a test number is available, make and receive a local, long distance, and digital subscription line telephone call.
 - b. Data Tests: These tests assume the Information Technology Staff has a network installed and is available to assist with testing. Connect to the network interface device at the demarcation point. Log onto the network to ensure proper connection to the network.
- D. Document data for each measurement. Data for submittals shall be printed in a summary report that is formatted similar to Table 10.1 in BICSI TDMM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.
- E. End-to-end cabling will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.

3.8 SYSTEM WARRANTY

- A. Contractor shall perform all labeling requirements and provide testing documentation for verification as described herein.
- B. Contractor shall submit cable records to reflect all moves, adds, and changes.

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- C. Contractor shall provide site plans showing locations of all telecommunication routes. See Item 3.6.
- D. Contractor shall submit final paperwork for warranty to manufacturer and a copy to the Owner one week prior to the substantial completion date.
- E. Contractor must be a certified as required by the owner and approved solution supplier such as Mohawk, Berk-Tek, Ortronics, and Siemens.
- F. Contractor must offer a minimum 20-year extended manufacturer's warranty for the premises fiber cabling solution comprised of approved manufacturer products and must follow all warranty registration procedures set forth by the manufacturer, including submitting all required documentation to the manufacturer for warranty certification.
- G. All installed equipment must conform to the manufacturer's official published specifications. The warranty shall begin at the system acceptance date and remain in effect for a period of 20 years (minimum) from that date. The contractor shall agree to repair, adjust, and/or replace, as determined by the owner and to replace defective equipment, materials, or other parts of the system at the contractor's sole cost. Owner will incur no costs for service or replacement of parts during the warranty period of 20 years. All third party warranties shall be passed through from the contractor to the owner.
- H. Contractor shall warrant that the system will function as specified in the approved manufacturer's Technical Description Guide.
- I. Contractor shall warrant that the system shall accommodate the specifications in all appropriate sections of this Request for Proposal and all applicable sections of the owners Specifications.

END OF SECTION

SECTION 27 1622 - CABLING FOR AUDIO-VISUAL SYSTEMS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Work covered by this Section shall consist of furnishing labor, equipment, supplies, materials, and testing unless otherwise specified, and in performing the following operations recognized as necessary for the installation, termination, and labeling of cabling and connectors as described on the Drawings and/or required by these specifications.
- B. Related Sections: The following Sections contain requirements that relate to this Section.
 - 1. Division 26, Section 26 0500 "Common Work Results for Electrical": Power supply, conduit and wiring.
 - 2. Division 27, Section 27 0500, Common Work Results for Communications.
 - 3. Division 27, Section 27 4100, Audio-Visual Systems.

1.3 REFERENCES

- A. Underwriters Laboratories Inc. (UL)
- B. International Code Council (ICC):
 - 1. International Building Code, 2009 Edition as adopted by State of New Mexico 2009 Commercial Building Code.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated. Include physical characteristics, UL classification types, conductor sizes, nominal impedances, and nominal capacitances. Reference each product to a location or "type" on Drawings. Test and evaluation data.
- B. Shop Drawings: The shop drawings listed below are required of the Contractor. Submit all Shop Drawings complete as a single submission. Isolated items will not be accepted, except with prior approval.
 - 1. Cabling Schedule: A list containing the cable type, cable marker identifier, and origination and destination location and connector types for each cable.
 - 2. Examples of the Contractor's final cable marking technique for each cable type.

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1.5 PRIOR APPROVAL

- A. For substitutions of products and/or manufacturers specified herein, Contractor shall submit requests for prior approval. Comply with provisions of Bidding Instructions and/or Division 1.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Protection: Protect products from damage that may be caused by exposure to water, chemicals, direct sunlight or infestation.
- B. Waste Management and Disposal: Separate waste materials for recycling in accordance with Division 01, Section "Construction Waste Management and Disposal".
 - 1. Remove packaging materials from site and dispose of at appropriate recycling facilities.
 - 2. Collect and separate for disposal paper, plastic, corrugated cardboard and/or polystyrene packaging materials in appropriate onsite bins for recycling.
 - 3. Dispose of all non-recyclable packaging materials and debris in a safe and environmentally responsible manner according to the instructions set forth by the General Contractor, local ordinances or codes and the Environmental Protection Agency.

PART 2 PRODUCTS

2.1 GENERAL

- A. Available Manufacturers: Subject to compliance with requirements, provide makes and models as listed below.
- B. The materials and products specified herein reflect the minimum acceptable standards of fabrication and manufacture. All materials and products supplied by the Contractor and specified herein are to be new, unused, of first quality and in original packaging or shipping containers or as shown on drawings and described in Part 3 below (for cabling).
- C. The products listed herein are pre-approved for this project. Substitutions shall be permitted for the manufacturers and products contained herein, provided they equal or exceed the specifications thereof and are pre-approved via formal request.

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2.2 BULK CABLING

NOTE: Not all cable types listed are used in this project.

2.03 Bulk Cables							
Type / ID	Signal Type	Cable Type	Manuraecture	Model-Part Number	OSP-Plenum	Nominal OD	Bend Radius
	Application						
				DIGITAL AUDIO CABLE			
Audio DA 01	24 AWG	24 AWG STP	Liberty	24-1P-Digi Audio 7 Stranded Annealed Copper	_____	0.165 Inch	4.06 Inch
Audio DA 01	AES3 / Mic/Line 1 Pair	24 AWG STP	Liberty	24-1P-P-Dig-Audio7 Stranded Annealed Copper	Plenum	0.17 Inch	3.30 Inch
Audio DA 01	AES3 / Mic/Line 1 Pair	24 AWG STP	Belden	1800B	_____	0.185 Inch	0.19 inch
Audio DA 01	AES3 / Mic/Line 1 Pair	24 AWG STP	Belden	1801B	Plenum	0.185 Inch	1.9 Inch
Audio DA 02	AES / Mic-Line 2 Pair	24 AWG 7X32	Belden	9729	_____	0.266 Inch	2.0 Inch
Audio DA 02	AES / Mic-Line 2 Pair	24 AWG 7X32	Belden	89729	Plenum	0.261 Inch	2.5 Inch
Audio DA 04	AES / Mic-Line 4 Pair	24 AWG 7X32	Belden	9728	_____	0.334 Inch	3.6 Inch
Audio DA 04	AES / Mic-Line 4 Pair	24 AWG 7X32	Belden	89728	Plenum	0.307 Inch	3.1 Inch
Audio DA 06	AES / Mic-Line 6 Pair	24 AWG 7X32	Belden	9731	_____	0.421 Inch	4.2 Inch
Audio DA 06	AES / Mic-Line 6 Pair	24 AWG 7X32	Belden	89731	Plenum	0.361 Inch	3.6 Inch
Audio DA 12	AES/Mice-Line 12 Pair	24 AWG 7X32	Belden	9734	_____	0.575 Inch	4.75 Inch

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Audio DA 12	AES/Mice-Line 12 Pair	24 AWG 7X32	Belden	89734	Plenum	0.498 Inch	5.00 Inch
ANALOG AUDIO							
AA 01	Mic/Line Audio 1 Pair	22 AWG STP	Belden	8450	_____	0.118 Inch	1.2 " Inch
AA 01	Mic/Line Audio 1 Pair	22 AWG STP	Belden	82761	Plenum	0.118 Inch	2.0 Inch
AA 01	Mic/Line Audio 1 Pair	22 AWG STP	Liberty	22-1P-EZ	_____	0.130 Inch	2.0 Inch
AA 01	Mic/Line Audio 1 Pair	22 AWG STP	Liberty	22-1P-CMP-EZ-?	Plenum	0.130 Inch	2.0 Inch
AA 02	Mic/Line Audio 2 Pair	22 AWG STP 2 Pair	Belden	8723	_____	0.160 Inch	1.6 Inch
AA 02	Mic/Line Audio 2 Pair	22 AWG STP 2 Pair	Belden	82723	Plenum	0.153 Inch	1.5 Inch
AA 02	Mic/Line Audio 2 Pair	22 AWG STP 2 Pair	Liberty	22-2P-INGSH-Gray	_____	2.02 Inch	2.02 Inch
AA 02	Mic/Line Audio 2 Pair	22 AWG STP 2 Pair	Liberty	22-2P-IPINSH-Wht	Plenum	0.157 Inch	1.27 Inch
LOUDSPEAKER							
LO 1	Loudspeaker (Constant Voltage)	18 AWG UTP (Shielded)	Belden	8461	_____	0.234 Inch	2.3 Inch
	Loudspeaker (Constant Voltage)	18 AWG UTP (Shielded)	Belden	6300U	Plenum	0.154 inch	1.5 Inch
	Loudspeaker (Constant Voltage)	18 AWG UTP (Shielded)	Liberty	18-2C-SH-Gray	_____	0.166 Inch	3.32 Inch
	Loudspeaker (Constant Voltage)	18 AWG UTP (Shielded)	Liberty	18-2C-PSH-Gray	Plenum	0.166 Inch	3.32 Inch

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	Loudspeaker (Constant Voltage)	16 AWG UTP (Shielded)	Belden	6200U	Plenum	0.18 Inch	1.8 Inch
LO 2	Loudspeaker (Constant Voltage)	16 AWG UTP (Shielded)	Belden	8471	_____	0.274 Inch	2.7 Inch
	Loudspeaker (Constant Voltage)	16 AWG UTP (Shielded)	Liberty	16-2C-Gray	_____	0.183 Inch	1.90 Inch
	Loudspeaker (Constant Voltage)	16 AWG UTP (Shielded)	Liberty	16 AWG-2C-PSH- WT	Plenum	0.192 Inch	1.92 Inch
	Loudspeaker (Constant Voltage)	16 AWG UTP (Shielded)	Belden	6200U	Plenum	0.18 Inch	1.8 Inch
LO 3	Loudspeaker (Low Impedence)	14AWG UTP (Shielded)	Belden	5100UH	_____	0.230 Inch	2.3 Inch
	Loudspeaker (Low Impedence)	14AWG UTP (Shielded)	Belden	6100FH	Plenum	0.234 Inch	2.34 Inch
	Loudspeaker (Low Impedence)	14AWG UTP (Shielded)	West Pen	295	_____	0.234 Inch	2.106 Inch
	Loudspeaker (Low Impedence)	14AWG UTP (Shielded)	West Penn	25295B	Plenum	0.222 Inch	2.1 Inch
LO 4	Loudspeaker (Low Impedence)	12 AWG UTP (Shielded)	Belden	5000 FE	_____	0.264 Inch	2.6 Inch

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	Loudspeaker (Low Impedence)	12 AWG UTP (Shielded)	Belden	6000 FE	Plenum	0.266 Inch	2.6 Inch
	Loudspeaker (Low Impedence)	12 AWG UTP (Shielded)	West Penn	AQ296	_____	0.375 Inch	2.106 Inch
	Loudspeaker (Low Impedence)	12 AWG UTP (Shielded)	West Penn	25295B	Plenum	0.222 Inch	1.998 Inch
RF Distribution							
RF 01	50 Ohm Antenna (Low Loss)	20 AWG Coax (RG 58)	Belden	8240	_____	0.193 Inch	1.6 Inch
	50 Ohm Antenna (Low Loss)	20 AWG Coax (RG 58)	Belden	88240	Plenum	0.159 Inch	1.6 Inch
	50 Ohm Antenna (Low Loss)	20 AWG Coax (RG 58)	Liberty	RG58-CMR	_____	0.195 Inch	3.90 Inch
	50 Ohm Antenna (Low Loss)	20 AWG Coax (RG 58)	Liberty	RG58-CMP	Plenum	0.195 Inch	3.90 Inch
RF 02	50 Ohm Antenna (Low Loss)	10 AWG Coax (RG-8 Type)	Belden	BL-89913	_____	0.405 Inch	3.6 inch
	50 Ohm Antenna (Low Loss)	10 AWG Coax (RG-8 Type)	Belden	9913	Plenum	0.285 Inch	3.6 Inch
	50 Ohm Antenna (Low Loss)	10 AWG Coax (RG-8 Type)	Liberty	LMR-400-FR	_____	0.405 Inch	5.6 inch

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	50 Ohm Antenna (Low Loss)	10 AWG Coax (RG-8 Type)	Liberty	RG8-CMP-BLK	Plenum	0.338 Inches	6.76 Inches
RF 03	75 Ohm TV Distribution	18 AWG Coax (RG6)	Belden	1530A	_____	0.27 Inches	2.75 Inches
	75 Ohm TV Distribution	18 AWG Coax (RG6)	Belden	1530AP	Plenum	0.27 Inches	2.75 Inches
	75 Ohm TV Distribution	18 AWG Coax (RG6)	Liberty	RG6-CCS-Quad Shield	_____	0.268 Inches	2.75 Inches
	75 Ohm TV Distribution	18 AWG Coax (RG6)	Liberty	RG6-P-CATV-Wht	Plenum	0.245 Inches	2.75 Inches
	75 Ohm TV Distribution	18 AWG Coax (RG6)	Comscope	4135303/10 WHT	Plenum	0.245 Inches	2.75 Inches
RF 04	75 ohm TV Distribution (RJ11)	14 AWG Coax (RG11 Type)	Belden	1523AP	_____	0.348 Inches	2.3 Inches
	75 ohm TV Distribution (RJ11)	14 AWG Coax (RG11 Type)	Belden	1523AP	Plenum	0.348 Inches	2.3 Inches
	75 ohm TV Distribution (RJ11)	14 AWG Coax (RG11 Type)	Liberty	RG11-Quad-PL	_____	0.372 Inch	2.3 Inch
	75 ohm TV Distribution (RJ11)	14 AWG Coax (RG11 Type)	Liberty	RG11-CATV-BLK	Plenum	0.405 Inch	2.3 Inch
	75 ohm TV Distribution (RJ11)	14 AWG Coax (RG11 Type)	Comscope	RG11 QUAD SHIELD WHT	Plenum	0.405 Inch	2.3 Inch
Category Cable							
CAT 1	CAT 6A Yellow For Video	23 AWG Cat 6 A Shielded Yellow	Liberty	24-4P-L6ASH-YEL	_____	0.296 Inch	2.75 Inch
	CAT 6A Yellow For Video	23 AWG Cat 6 A Shielded Yellow	Liberty	24-4P-P-L6SH-YEL	Plenum	0.296 Inch	2.75 Inch

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	CAT 6A Yellow For Video	23 AWG Cat 6 A Shielded Yellow	True Cable	6ASCMPYEL	Plenum	0.299 Inch	2.75 Inch
	CAT 6A Yellow For Video	23 AWG Cat 6 A Shielded Yellow	True Cable	6ASCMRYEL	_____	0.297 Inch	2.75 Inch
	CAT 6A Yellow For Video	23 AWG Cat 6 A Shielded Yellow	Comscope	CS34P YEL C6	Plenum	.273 Inch	2.75 Inch
CAT 2	CAT 6 Green (For Control)	23 AWG Cat 6 Non Shielded Green	Liberty	24-4P-P-L5-EN-GRN	Plenum	0.22 Inch	2.2 Inch
	CAT 6 Green (For Control)	23 AWG Cat 6 Non Shielded Green	True Cable	6ECMPGRN	Plenum	0.244 Inch	2.2 Inch
	CAT 6 Green (For Control)	23 AWG Cat 6 Non Shielded Green	Comscope	CS34P GRN C6	Plenum	.273 Inch	2.25 Inch
CAT 3	Cat 6 White (For Misc USB Extend etc.)	23 AWG Cat Non Shielded White	Liberty	24-4P-P-L6-EN- WHT/GRAY	Plenum	0.195 Inch	1.25 Inch
	Cat 6 White (For Misc USB Extend etc.)	23 AWG Cat Non Shielded White	True Cable	6ECMPWHT/ GRAY	Plenum	0.192 Inch	1.75 Inch
	Cat 6 White (For Misc USB Extend etc.)	23 AWG Cat Non Shielded White	Comscope	2071E-UTG	Plenum	0.195 Inch	1.75 Inch
CAT 4	Shielded Cat 6 Black (Dante)	23 AWG Cat 6 Non Shielded BLK	True Cable	6ESCMPBLK	Plenum	0.195 Inch	2.0 Inch

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	Shielded Cat 6 Black (Dante)	23 AWG Cat 6 Non Shielded BLK	Liberty	24-4P-P-L6-EN-BLK	Plenum	0.195 Inch	1.25 Inch
	Shielded Cat 6 Black (Dante)	23 AWG Cat 6 Non Shielded BLK	Comscope	CS34P BLK	Plenum	.273 Inch	1.25 Inch
Serial Digital - Composite Video							
DV 01	Serial Digital - Composite Video	20 AWG Coax (RG 59U)	Belden	1505A	_____	0.233 Inch	2.3 Inch
	Serial Digital - Composite Video	20 AWG Coax (RG 59U)	Belden	1506A	Plenum	0.233 Inch	2.0 Inch
	Serial Digital - Composite Video	20 AWG Coax (RG 59U)	Liberty	20-CMR-Video COAX	_____	0.236 Inch	2.36 Inch
	Serial Digital - Composite Video	20 AWG Coax (RG 59U)	Liberty	20-CMP-VID-COAX	Plenum	0.236 Inch	2.07 Inch
DV02	Serial Digital (HD-SDI), Coax, Video (CVBS) Bundle of 3	20 AWG Coax (RG 59U)	Belden	7794A	_____	0.706 Inch	7 Inch
	Serial Digital (HD-SDI), Coax, Video (CVBS) Bundle of 3	20 AWG Coax (RG 59U)	Liberty	RGB3C-20-CMR	_____	0.630 Inch	7 Inch
DV03	Serial Digital (SDI), Video (CVBS) Bundle of 4	20 AWG Coax (RG 59U)	Belden	7795A	_____	0.235 Inch	7 Inch

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	Serial Digital (SDI), Video (CVBS) Bundle of 4	20 AWG Coax (RG 59U)	Belden	7795A	_____	0.235 Inch	7 Inch
DV04	Serial Digital (SDI), Video (CVBS) Bundle of 10	20 AWG Coax (RG59U)	Belden	7798A	_____	1.166 Inch	11.5 Inch
Fiber Optic's Multi Mode							
F01	MM Fiber (2 Strand)	OM4 Multimode	Extron	22-225-02	Plenum	2.0 Inch	Bend Insensitive
F02	MM Fiber (4 Strand)	OM4 Multimode	Comscope	004T8P-31190-29	Plenum	2.1 Inch	2.09 Inch
		OM4 Multimode					
F03	MM Fiber (6 Strand)	OM4 Multimode	Comscope	006T8P-31190-29	Plenum	2.1 Inch	2.09 Inch
F04	MM Fiber (12 Strand)	OM4 Multimode	Comscope	012T8P-31190-29	Plenum	2.1 Inch	3 Inch
Fiber Optics Single Mode							
F05	SM Fiber (2 Strand)	Single mode OS2	Comscope	L-002-DS-GF-	Plenum	.197 Inch	3 Inch
F06	SM Fiber (4 Strand)	Single mode OS2	Comscope	760004325/P-004-DS-8W-FSUYL	Plenum	.197 Inch	2.52 Inch
F07	SM Fiber (6 Strand)	Single mode OS2	Comscope	CableWholesale	Plenum	.199 Inch	2.0 Inch

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F08	SM Fiber (12 Strand)	Single mode OS2	Comscope		Plenum		
Control							
C01	24 AWG STP 3 Pair	IR-Serial-RS232- RS485	Belden	8104	_____	.302 Inch	2.5 Inch
			Belden	82503	Plenum	.250 Inch	2 Inch
			Liberty	24-4P-SH-LIB	_____	.225 Inch	4.50 Inch
			Liberty	24-4P-PLCSH	Plenum	.210 Inch	4.2 Inch
C 02	24 AWG 2 Pair STP	Serial Control (RS-485-DMX 412 (4 Conductor)	Belden	9842	_____	.340 Inch	3.5 Inch
			Belden	82842	Plenum	.273 Inch	3.25 Inch
			Liberty	24-2P-485-WHT	_____	.326 In	6.52 Inch
			Liberty	24-2P-P485-WHT	Plenuim	.210 Inch	4.2 Inch
C03	24 AWG STP (1Pair)	Dry Contact & Signal in/out	Belden	8761	_____	.175" Inch	1.8 Inch
	24 AWG STP (1Pair)	Dry Contact & Signal in/out	Belden	82761	Plenum	.116 Inch	1.8 Inch
HDMI							

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Type	Mfgr	Part #	Model #	Description	HDMI Ver	Speed	Bend Radius
HDMI 01	Extron Ultra 3 Foot	236-663-03	HDMI Pro 3'	3' 4K HDMI Cable M-M Type A	2	18 Gbs	1 Inch
	Liberty Kinetic 3Foot	HDPMM03F	Kinect Series 3'	3- 4K HDMI Cable M-M Type A	2	18 Gbs	1.2 Inch
HDMI 02	Extron Pro 6 Foot	26-663-06	HDMI Pro / 6	6' Pro Cable M-M Type A	2	18 Gbs	1 Inch
	Liberty Kinetic 6 Foot	HDPMM06F	Kinetic Series 6'	6' Kinitic Cable M-M Type A	2	18 gbs	2.36 Inch
HDMI 03	Extron Pro 12 foot	26-663-12	Pro /12'	12' Cable M-M Type A	2	18 Gbs	1 Inch
	Liberty Kinetic 10 foot	HDPMM10F	Kenitic series 12'	10' HDMI Cable M-M Type A	2	18Gps	2.36 Inch
HDMI 04	Extron Pro 15 foot	26-663-15 Foot	Pro / 15'	15' HDMI Cable M-M Type A	2	18 Gbs	4.10 Inch
	Liberty Kinetic 15 Foot	HDPMM15F	Kenitic Series 15'	15' HDMI Cable M-M Type A	2	18Gps	2.36 Inch
HDMI 05	Covid Active 35 foot Copper	P-HD28-35RM	4K-18G	35' Copper HDMI Cable M-M Type A Plenum	2	18 Gbs	4.5 Inch
	Kramer 35 Foot Copper	CP-HM/HM/ETH-35	4K-18G	35' Copper HDMI Cable M-M Type A Plenum	2	18 Gbs	3.347 Inch
Fiber-Hybred HDMI							
HDMI 06	50 Foot Kramer Hybrid Fiber	CP-AOCH/60-50	HDMI Fiber-Hybrid	50 foot Hybrid Fiber with detachable Heads	2.2	18 Gbs	
	BTX 50' Hybrid Fiber w-Detachable Heads	BTX-AOCHDM50H	HDMI Fiber-Hybrid	50 foot Hybrid Fiber with detachable Heads	2	18 Gbs	

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	Covid 50' Hybrid Fiber w- Detachable Heads	P-HDADC-50	HDMI Fiber-Hybrid	50 foot Hybrid Fiber with detachable Heads	2.2	18 Gbs	
HDMI 07	75 foot Covid Hybrid Fiber w- detachable head	P-HDADC-75	HDMI Fiber-Hybrid	75 foot Hybrid Fiber with detachable Heads	2.2	18 Gps	
	75' Kramer Hybrid Fiber w Detachable Head	CP-AOCH/XL-328	HDMI Fiber-Hybrid	75 foot Hybrid Fiber with detachable Heads	2.2	18 Gps	
	75' Foot BTX Hybrid Fiber	BTX AOCHEM75	HDMI Fiber-Hybrid	75 foot Hybrid Fiber cable	2	18 Gps	
USB							
USB 1	3' USB 3.0 A (M) to USB B (M)	USBA-AB-03	Covid	3' USB Male A to USB Male B	Backwards Compatable		
	3' USB3.0 A Male to B Male	E-USB3AB-03	Liberty	3' USB Male A to USB Male B	Backwards Compatable		
USB 2	6' USB 3.0 A (M) to USB B (M)	USB3AB-06	Covid	6' USB Male A to USB Male B	Backwards Compatable		
	6' USB 3.0 A (M) to USB B (M)	E-USB3AB-03	Liberty	6' USB Male A to USB Male B	Backwards Compatable		
USB 3	10' USB 3.0 A (M) to USB B (Male)	USB3-AB-10	Covid	10' USB Male A to USB Male B	Backwards Compatable		

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	10' USB 3.0 A (M) to USB B (Male)	E-USB3AB-10	Liberty	10' USB Male A to USB Male B	Backwards Compatable		
USB 4	35' USB A (Male) to A (Female) Active	P-USBA-AF-35ACT	Covid	35' USB Male A to USB Female B Plenum	Backwards Compatable		
	35' USB A (Male) to A (Female) Active	DL-PLUSB3.1AAF-010M	Liberty	35' USB Male A to USB Female B Plenum	Backwards Compatable		
USB-5	50' USB A Male to Female	P-USB3A-AF-50ACT	Covid	50' USB Male A to USB Female B Plenum			
	50' USB A Male to Female	DL-PLUSB3.1AAF-015M	Liberty	50' USB Male A to USB Female B Plenum	Backwards Compatable		
USB 6	1' USB A (M) A (MALE)	USB-AA-01	Covid	1' USB A Male to A Male	USB 2.0		
USB 7	3' USB A (M) A (MALE)	USB-AA-03	Covid	3' A Male to A Male	USB 2.0		
	3' USB A (M) A (MALE)	E-USB3AA-03	Liberty	3' A Male to A Male	Backwards Compatable		

PART 3 EXECUTION

3.1 STANDARDS

- A. All cabling and termination shall be executed in adherence to standard industry practices such as those outlined in the following:
1. NECA 1, Good Workmanship in Electrical Contracting
 2. Philip Giddings, *Audio Systems Design and Installation*. Boston: Focal Press, 1990.
 3. Kenneth T. Deschler, *Cable System Design and Installation*. McGraw-Hill, Inc. 1987.
 4. InfoComm International, *AV Installation Handbook – Second Edition: The Best Practices for Quality Audiovisual Systems*. InfoComm International, 2007. Fairfax, VA

3.2 EXAMINATION

- A. Site Verification of Conditions:
1. Verify that conditions of substrates and pathways previously installed under other sections or contracts are acceptable with cable installation.
 2. Inform Owner of unacceptable conditions immediately upon discovery.
 3. Proceed with installation only after unacceptable conditions have been corrected.

3.3 CABLE LENGTHS

- A. Cable Length Verification: Cable lengths where given in the Specification, for bulk or manufactured cable assemblies, have been provided to assist the Contractor in the bidding process. Cable run lengths, where specified, are end-point-to-end-point estimates and include consideration for tails. Estimates may be based upon cable tray systems; raceways, conduit runs, and furniture layouts indicated on construction drawings and may vary from the actual installed cable pathways. It is responsibility of the Contractor to field verify required cable lengths for bulk cable or manufactured cable assemblies prior to ordering.

3.4 INSTALLATION

- A. Non-contiguous cable support mechanisms such as hangers, rings, and hooks shall not be spaced farther than four (4) feet apart. All manufactured raceways used for cables shall be installed according to the raceway manufacturer's specifications.
- B. Cable runs shall be supported with devices designed for this purpose and are to be installed independent of any other structural component.
- C. Cables routed vertically up walls, or between floors as vertical riser, shall be supported with clamps or other mechanisms. These supports shall occur at least three times per floor.

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- D. Cable pulling tension may not exceed manufacturer recommendations. Where cable-pulling lubricant is used, the lubricant must be compatible (non-damaging) with the conduit and cable sleeve materials and must not harden over time to prevent future pulls.
- E. Cable stapling of any recognized media type shall not be permitted.
- F. Cables shall be dressed in conveniently sized bundles and either laced or banded. Lacing or banding shall not be so tight as to deform cable bundles.
- G. Cabling installed with a bend radius less than that recommended by the cabling manufacturer is not acceptable.
- H. Cables and bundles terminating at equipment or connector panels shall be supported so as not to put strain on connections or connectors.
- I. All cables, with the exception of video or pulse cables, which must be cut to an electrical length, shall be cut to the length dictated by the run. No splices shall be permitted in any pull boxes without prior approval of the Consultant.
- J. Cabling for equipment mounted in drawers or on slides shall be provided with a service loop of appropriate length. A cable management support for the service loop shall be provided to prevent the service loop travel from interfering with the operation of the drawer or slide, or snagging on adjacent cabling.
- K. Install wiring in raceway and cable tray except within consoles, cabinets, desks, and counters. Conceal raceway and wiring except in unfinished spaces.
- L. Microphone level, line level, loudspeaker level, and video lines shall all be run in separate conduits, trough, raceway divider, and cable bundles. Low voltage DC and control may be run along with any but microphone- or line- level audio cable runs.
- M. Use NRTL-listed plenum cable in environmental air spaces, including plenum ceilings. Conceal raceway and cables except in unfinished spaces.
- N. Install LAN cables using techniques, practices, and methods that are consistent with Category 5E/6 rating of components and that ensure Category 5E/6 performance of completed and linked signal paths, end to end.
- O. Install cables without damaging conductors, shield, or jacket.
- P. Repair damage to adjacent materials caused by cable work.

3.5 TERMINATION

- A. Contractor to follow approved Manufacturer procedures for termination instructions for the specific products being installed.
- B. All termination components must meet or exceed all specifications for given media type and

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application as described in this document and system drawings.

- C. Crimp on connectors shall be installed only on the appropriate size cable using the manufacturer recommended crimp tool and die set.
- D. Connections to electronic devices providing screw terminals shall be terminated using the appropriate gauge insulated spade or ring crimp terminal connector and crimp tool.
- E. All mechanical solder-on connectors shall be attached to cable ends using rosin core solder.
- F. Audio signal cable shields shall be protected with the appropriate gauge Teflon or heat-shrinkable tubing. The jacket end of each audio cable shall be fitted with the appropriate gauge heat shrinkable tubing to provide additional protection to the base of the shield or shield foil. This also applies to the inside of mechanical connectors and cables that terminate at partitioned barrier strips.

3.6 GROUNDING

- A. Comply with Division 26 requirements for grounding and bonding for electrical systems.
- B. Comply with IEEE 1100, "Power and Grounding Sensitive Electronic Equipment."
- C. Ground cable shields, drain conductors, and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
- D. Bond shields and drain conductors to ground at only one point in each circuit.

3.7 IDENTIFICATION

- A. In addition to requirements in this Article, comply with applicable requirements in Division 26 requirements for identification for electrical systems and with TIA/EIA-606.
- B. Labeling:
 - 1. Label products in a logical, legible and permanent manner corresponding to the Drawings. Wording, format, style, color and arrangement of text will be subject to the Architect's approval.
 - 2. Label all wall plates for input, output and control receptacles as well as connector mounting plates in floor boxes using 1/8" engraved lettering filled with black paint if plate is light colored and filled with white paint if plate is dark colored.
 - 3. Provide engraved labels similar to Lamicoid, Traffolyte or equal and approved, squarely and permanently attached to label patch panels, barrier strips, terminals, transformers, switches, relays and similar devices as well as front and rear of all signal processing equipment (e.g. PA, LIM, EQ). Label all controls on distribution amplifiers, mixers, etc. as to the function of each.
 - 4. Label all permanent wiring on both ends with approved permanent clip-on type or sleeve type markers. Wrap-around adhesive labels will not be accepted unless completely

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covered with clear heat shrink tubing.

5. Label all portable equipment with permanent labels showing ownership by Owner. Label all portable cables similarly with printed heat-shrinkable tags located 12 inches from the male connector end. Use 1/8" block letters and verify acceptability of wording with the A/V Design Consultant prior to engraving or printing labels.
6. Sample labels:

(DVD Wire End)(Router Wire End)

CABLE # A107 DVD-1 AUDIO IN L ROUTER AUDIO OUT 12L	CABLE # A107 ROUTER AUDIO OUT 12L DVD-1 AUDIO IN L
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- C. At completion, all cabling labels and schedules shall reflect as-built conditions.

3.8 CLEANING

- A. Upon completion, remove surplus materials, trash, tools and equipment.

END OF SECTION

SECTION 27 4100 - AUDIO-VISUAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SCOPE OF WORK

- A. Work covered by this Section shall consist of furnishing labor, equipment, supplies, materials, and testing unless otherwise specified, and in performing the following operations recognized as necessary for the installation, termination, testing, and labeling of all telecommunications infrastructure as described on the Drawings and/or required by these specifications.
- B. Furnishing equipment, cabling, supplies, and materials
- C. Furnishing labor for installation, testing, software programming, and user training.
- D. Third-party testing and commissioning
- E. Service and maintenance contract
- F. All other operations not described herein but are necessary for a complete functioning system shall adhere to the performance parameters described on the drawings and/or required by these specifications.
- G. Related Sections: The following Sections contain requirements that relate to this Section.
 - Division 11, Section 11 5213, Projection Screens.
 - Division 26, Section 26 0500, "Common Work Results for Electrical": Power supply, conduit and wiring.
 - Division 27, Section 27 4111 Projection mounts
 - Division 27, Section 27 0500, Common Work Results for Communications.
 - Division 27, Section 27 1622, Cabling for Audio-Visual Systems.
 - Division 27, Section 27 4181, Audio-Visual Control Systems.
 - Division 27, Section 27 4224, Digital Signage Video Displays.

1.3 REFERENCES

- A. Underwriters Laboratories Inc. (UL)
- B. International Code Council (ICC):
- C. International Building Code, Latest Edition adopted by State of New Mexico Commercial Building Code.
- D. AVIXA CTS Manual
- E. National Electrical Code, Latest Edition

1.4 DEFINITIONS

- A. Terms:
 - 1. Bidder: Entity generating the bid response.
 - 2. Contractor: Successful Bidder to whom the Owner has awarded the contract.
 - 3. Installer (a.k.a. “Audiovisual Systems Integrator” or similar): Actual entity providing the audiovisual systems installation. Generally equivalent to “Contractor” or else a sub-contractor hired by the Contractor.
 - 4. Furnish indicates the responsibility to ship or deliver the item to the job site, freight prepaid, for receipt, staging and installation by others.
 - 5. Install or Installation: Indicates the responsibility of receiving the item at the job site, providing adequate storage, unpacking or uncrating the item, physically securing the item or otherwise making ready the item for its intended use by following the instructions and approved methods of the manufacturer and those contained herein.
 - 6. Provide indicates the responsibility to both “Furnish” and “Install.”
 - 7. Installation Materials: Shall refer to installed materials, which may or may not be explicitly specified herein, but which are essential to a complete functioning system such as the following:
 - a. Concealed cabling, exposed and/or loose cabling, cable terminations, cable adapters, cable management, cable labeling, cable dressing, and patch cords (voice, data, audio and/or video)
 - b. Custom connection panels and/or blank cover panels for rough-in devices (wall boxes, floor boxes, ceiling boxes, cubbies) or rack-mounted termination/patch fields
 - 8. NIC or Not In Contract: Equivalent to “Provided by Others”.
 - 9. OFCI or Owner Furnished Contractor Installed: Shall refer to equipment that will be furnished by the Owner for installation by the Contractor. The Contractor shall be responsible install and integrate as detailed herein.
 - 10. The term “shall” is mandatory; the term “will” is informative; and the term “should” is advisory.
 - 11. Format or Aspect Ratio: Proportion of image area expressed as a ratio of width/height.

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- a. 16:9 or “HD” or “HDTV” Wide Format: 2.35
- b. 16:10 or “Computer” Wide Format: 1.85.1.
- c. 4:3 or NTSC, SD or SDTV Legacy Video Format 1.33.1

B. Acronyms:

1. ADA: Americans with Disabilities Act
2. ALS: Assistive Listening System intended for persons with hearing disabilities
3. AV: Audio-Video or Audio-Visual
4. BGM: Background Music
5. CATV: Community Access Television (aka “cable television”)
6. CPU: Central Processing Unit
7. DANTE AUDIO: Replaces analog audio equipment and cabling with a computer network
8. DSP: Digital Signal Processor mainly used for audio
9. DVD: Digital Video Disc or Digital Versatile Disc. This acronym refers to the standard optical disc format for playback of audiovisual and/or multi-media.
10. BLU-RAY: BLU-RAY is a digital optical disc storage format. It is designed to supersede the DVD format, and capable of storing several hours of high-definition video.
11. FPD: Flat Panel Display
12. LCD: Liquid Crystal Display, a type of flat panel display
13. LED: Light Emitting Diode display a type of flat panel display
14. OLED: OLED’s Pixels produce their own light on a pixel-by-pixel basis a type of flat panel display.
15. NanoCell: NanoCell offers better image quality and dynamic range than other LED TVs with bright, vivid, accurate colors. A type of flat panel display.
16. LASER PROJECTOR: The main visual benefit of laser projection is that laser light sources offer better color accuracy – often called a wider color gamut. In addition to the colors themselves, laser projectors offer better brightness uniformity and lower brightness decline over the lifetime of the projector.
17. BULB PROJECTOR: The Projector Lamp, otherwise known as the a projector bulb, is a replaceable part of the projector that needs to be maintained according to the lamp life of the projector, which averages between 1,000 and 2,000 hours
18. TV: Television
19. MATV: Master Antenna Television distribution system
20. RF: Radio Frequency
21. IR: Infrared sometimes-called infrared light used as a control protocol for controlling AV equipment.
22. RS 232: RS232 stands for "Recommended Standard 232" and is a type of serial communication used for controlling devices that accept RS 232. This is a 2 way communication protocol

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23. IP: Internet Protocol
24. IT: Information Technology
25. LAN: Local Area Network
26. WAN: Wide Area Network.
27. PC: Personal Computer. This acronym applies to stationary “tower” or “desktop” workstations, in addition to portable “notebook” or “laptop” computers.
28. Streaming is a method of viewing video content without actually down loading the media files.
29. UPS: Uninterruptible Power Supply.
30. USB: Universal Serial Bus, a serial bus standard to interface data devices.
31. Media Player hardware or software to play media content

1.5 SYSTEM NARRATIVE

- A. Large Conference 102 & 103
 1. These 2 rooms can be combined and uncombined as needed.
 - a. In the uncombined mode, each room is independent. Only the sources and destinations for that room will be available.
 - b. In the combined mode, 1 room becomes the master room. The other rooms touch panel is locked out with a splash screen that tells the operator that the room is in the combined room mode.
 - c. All sources from both rooms are available in the combined mode.
 2. The rooms are AV over IP using Zee encoders and decoders
 3. There are 4 86” LCDs controlled by a Crestron Or Equivalent control processor.
 4. There are 2 7” wall-mounted touch panels near each rooms teaching area
 5. There is a BYOD device for each Room
 6. There are two cameras per room for soft codecs these cameras can be shared between the two rooms and are able to be displayed on the displays in each room
 7. The audio for each room will follow what is being displayed on the front of room display
 8. All displays will be professional series.
- B. Lobby – Digital Signage: Refer to Section 27 4224
 1. This is a digital Signage area
 2. The display is a 55” LCD with a tilting wall mount
 3. The owner provided minicomputer would be mounted behind the display.
 4. The display will be attached to the owner’s network.

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- C. Meeting Room 171, 108 & 145
 - 1. These 3 rooms are similar to each other.
 - 2. The displays are 65 to 75" LED displays mounted on Chief LTMAU Tilting wall mounts.
 - 3. Each room will have a Polycom Studio sound bar w- Camera to be used for zoom, team soft codec software.
 - 4. The sound bar has a built microphone array and speakers for room sound.
 - 5. The push button controller will provide a display On/Off, Source select, and room volume. re no camera control from the button panel. The camera is to be controlled via the Polycom remote.

1.6 DESIGN PRINCIPLES

- A. Flexibility: The facility's cable pathway infrastructure (utilized for audiovisual signals, as well as relevant data/voice and AC power signals) shall be sufficiently flexible to allow future expansion of the audio visual systems. Design parameters for such expansion are in accordance with the Owner's long-term goals and expectations for such systems, as outlined within this section.
- B. There shall be a 6-foot service loop at the projector, and a 6-foot service for all other cables. The service loop shall be located coiled above the ceiling near the destinations connector.
- C. The service loop for the racks is to be coiled above the ceiling. The service loops for other equipment will be coiled above the ceiling. A method of hanging the service loops is required.
- D. Cost Effectiveness: The AV systems shall utilize limited resources with utmost efficiency. Emphasis lies on common usability and current technology standards, and not on emerging technology trends or enhanced features.
- E. Ease of Operation: The AV systems shall require a minimal amount of Owner training for successful operation. User interfaces (control panels, signal connection panels, etc.) shall have a consistent look and feel throughout the facility.
- F. Sustainability: The AV system is designed with a high degree of reliability in mind. Operation of such systems shall require minimal ongoing maintenance, as well as minimal investment by the Owner in dedicated support personnel. It is that the Owner establish an agreement with the AV systems integrator, to secure warranty service calls and/or ongoing maintenance support.
- G. Network Connectivity: With the convergence of audiovisual and information technologies, careful planning must occur to ensure that network connectivity is provided for IP-enabled audiovisual devices and systems. Telecommunications outlets and their port quantities must be coordinated to meet or exceed the requirements of the appropriate audiovisual equipment. Discussion with the Owner's IT staff/entity will be required to ensure proper coordination between the audiovisual systems and the network design.
- H. Each network device that has a static IP shall be labeled on the front and the rear with the units IP address, Subnet, Login information (Login and Password)

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- I. If the device is using DHCP, the assigned information for that piece should reserve in the DHCP server. IP Address, subnet, logon password if any should be labeled on the front and the rear of that device.
- J. Button control systems will have its labels laser engraved.
- K. Hook and loop Velcro will be used on all cable pulls that are bundled or secured to a rack.
 - 1. Cables of the same color will be bundled together. These bundles will be kept separated in the racks, furniture ext.
 - 2. Cables that are attached to cable trays will be bundled in the same colors. If the cable tray is being used for IT cabling the AV cables will be bundled and secured to J-hooks along the bottom of the cable trays.
 - 3. The use of cable ties shall be held to the bare minimum.

1.7 PERFORMANCE REQUIREMENTS

- A. All Audiovisual Systems shall interface and be compatible with each other.
- B. Audio
- C. Analog
 - 1. Polarity: Absolute signal polarity should be maintained throughout the signal chain such that a positive signal at the input produces a corresponding positive excursion at the loudspeakers.
 - 2. Electronics: The audio system electronics shall deliver the following minimum performance standards as measured from all source inputs for microphones, disc and/or cassette playback devices, etc., through all mixers, audio distribution amplifiers, routers, etc., to all audio signal destinations.
 - a. Frequency Response: +/- 0.5dB, 20-20,000 Hz
 - b. Hum and Noise: -70 dBu, 20-20,000 Hz, un-weighted
 - c. Distortion: 0.1% THD, 20-20,000 Hz
 - 3. Speech Signal: The system shall provide a speech signal in the audience seating area that meets the following requirements:
 - a. Frequency response within +/- 3 dB from 500 Hz to 15,000 Hz.
 - b. Overall SPL variance of +/- 3 db.
 - c. Measured percentage articulation loss of consonants (Alcons) of 10% or lower.
 - d. Maximum average SPL of 90 dB (flat), with 10 dB of undistorted headroom available.
 - 4. Digital audio
 - a. Optical
 - b. Digital audio is a technology that is used to record, store, manipulate, generate and reproduce sound using audio signals that have been encoded in digital form. It also

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refers to the sequence of discrete samples that are taken from an analog audio waveform.

5. Dante
 - a. The Dante/MTX/MRX network will not join with an existing local area network or include some other network devices (however, the control network for applications such as MTX-MRX Editor or Wireless DCP can be used together with the Dante network).
 - b. Integrator will not be using multicast flows (only relevant if you are using Dante Controller).

D. Network switch

1. A non-blocking layer-2/3 gigabit switches w- POE & PoE+
2. All the ports are capable of simultaneous gigabit transfer (whether the switch is non-blocking), determine whether the switching capacity is at least $1 \text{ GBPS} \times \text{the number of ports} \times 2$ (for in and out).
3. Capable of switching off Energy Efficient Ethernet (EEE) and other power-saving features
4. We recommend managed (intelligent) switches that can be configured and monitored.
5. We recommend switches that support DiffServ (DSCP) Quality of Service (QoS) with strict
 - a. Category cable shall be terminated using the TIA 528 B standard.
 - b. Shielded Category 6A will be used for all Digital Video runs.
 - c. 360 degree shielded Cat 6A RJ 45 connectors will be used all shielded category cable.
 - d. There will be no more than 3 interconnect points per cable run
 - e. Where possible direct runs are preferred
 - f. Video Category 6/6A shielded cabling will have a yellow jacket. This is used for video sources.
 - g. Non-Shielded Category 6/6A will have a green jacket. This is used for system control lines, Network switch for control.
 - h. Non Shielded Category 6/6A will have an orange jacket. This is used for Misc. connections i.e. Touch panels, USB extenders, and like items.
 - i. Shielded Cat 6/6A is used for Dante audio will have a purple jacket
 - j. Premade category cable of the correct color are recommended for interconnects in the rack.
 - k. Premade cables will be used to interface the touch panel, USB Extenders or any other product that gets moved around its assigned area. These cables must allow the customer to move the device up to 8'. Excess cable will be coiled and strapped with Velcro one wrap tape.
 - l. Cables will be bundled in their color in the rack.

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- m. Velcro hook and loop tape should be used to bundle all the Category cables. Wire ties are not a Cables of the same color or function will be dressed in separate bundles in the rack. i.e. Yellow with yellow, orange with orange, And green with green.
 - n. All cabling will be dressed in the rack to make it easier to identify what the color is used for.
 - o. Cabling in the rack must have a service loop so equipment can be removed from the rack without having to disconnect the equipment.
 - p. If there is no interconnect panel and the cables are coming thru a feed thru wall plate than a 10' Whip will be used to allow the end user to move the rack or podium.
 - q. This whip should be covered with a black general purpose braided cable sleeve. It is the contractor's choice to use a full braid or a wraparound material.
 - r. Cable Labels will be 6" back from that cables connector
- E. Product Samples (upon request):
- 1. Cabling and connectors – typical for each type
 - 2. Cable marking samples: As described in Section 27 1622.
 - 3. Equipment labels
 - 4. Connection panel / faceplate with etched engraving
 - 5. Equipment rack identification panel – refer to paragraph (F) below.
- F. Field quality-control test reports: For speech and program audio amplification systems identified herein to ensure proper speech intelligibility, gain-before-feedback, loudness and coverage uniformity under typical operating circumstances.
- 1. Class 2 Sound Level Meter, 30-130DBA Range SPL Meter, Max/Min Data Hold, A/C Mode, LCD Back Light, Portable. Measure ambient noise levels with all normal systems operating (HVAC, lighting, etc.) and with all components of sound reinforcement system powered on without any amplified signal.
 - 2. Measured electrical impedance for all loudspeaker channels. 4, 6, 8 or 16 ohm
 - 3. Plots of system Reverberation Time (RT) measurements.
 - 4. Plots of system Sound Pressure Level (SPL) histograms.
- G. Equipment Rack Identification Panel:
- 1. Within each room containing equipment racks for audio-visual systems, a custom graphical identification shall be installed within one (1) of the equipment's rack(s) in that room. All audio-visual racks in the facility shall be identical aside for information specific to the associated room or system type.
 - 2. Submit graphical layout of this panel to the owner or consultant for review using a common digital image format such as JPEG, GIF, TIFF or bitmap.
 - 3. The panel design should include the following as a minimum- NO EXCEPTIONS
 - 4. Integrators name and contact information
 - 5. Design Consultants name

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6. Owners name and a brief description / identifier of the project or system type.
7. One Red RJ 45 for Cat 5E for system programming.

1.8 SUBMITTALS

- A. Product Data: For all proposed equipment, cables and connectors, and faceplates for evaluation of technical features. Reference each product to a location on Drawings. Include the following:
 1. Manufacturer's submittal sheet (if applicable).
 2. Manufacturer's published specification "cut" sheets.
 3. Operating characteristics, furnished specialties, and accessories.
 4. Physical data (dimensions, weight, line art and/or photos).
 5. Test and evaluation data (frequency and phase plots at on-axis and multiple off-axis incidence angles, impedance plot, 1/3-octave polar coverage patterns, etc.)
- B. Shop Drawings: The shop drawings listed below are required of the Contractor. Submit all Shop Drawings complete as a single submission. Isolated items will not be accepted, except with prior approval.
 1. System Narrative: Concise narrative description of the system's performance capabilities, physical connection topology, and sequence of operation for each different "scene" or "mode".
 2. Wiring Schematic / Connection Diagram: Detailed wiring diagrams showing interconnection of components and products, wiring and cabling diagrams depicting cable types and designators, and device designators. Provide connector designations and terminal strip identification, along with color codes for cables connecting to these devices. Give each component a unique designator and use this designator consistently throughout the project.
 3. Diagrams for cable management system – e.g., inside equipment racks, in cable tray, etc.
 4. Cabling Schedule: A list containing the cable type, cable marker identifier, and origination and destination location and connector types for each cable.
 5. Mounting Details for Loudspeakers: Scaled drawings of complete mounting details, hardware and support surfaces, including details on all load requirements, safety factors, and structural materials.
 6. Panels: Scaled drawings of interconnect panels.
 7. Equipment & Panel Labels: A list containing the identifier label for all panels and rack mounted equipment. Include information on label type and construction.
 8. Equipment Rack Layouts: Fully detailed rack drawings (rack front elevations) indicating equipment orientation within the equipment rack.
 9. Cable Routing / Riser Diagram: Diagram showing conduits/pathways for audio and control cabling with clear indications of which cables will be installed in each pathway. Cabling installed in each pathway may be called out via tags on the diagram or via cable run schedule(s) included with the diagram. All cable runs shall be identified with cable ID tags which match those shown on the connection diagram/signal flow diagram described above.

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10. Consultant's floor plan and enlarged plan project document sheets in electronic format are available to be supplied to the Contractor (upon formal request) for their use as part of submittals. Consultant's detail and diagram sheets in electronic format shall not be provided to the Contractor. Shop drawing submittals containing information copied directly from the Consultant's document sheets without addition of proposed installation or configuration information shall be rejected.

1.9 QUALITY ASSURANCE

- A. Installer Qualifications: As part of the Bid Response, the Contractor shall furnish evidence of his/her qualifications to perform the work specified. Evidence of Contractor qualifications shall include the following:
 1. The Bidder's installation team members shall include at least one
 2. Crestron Digital Media Installer DMC-I) and shall be on site
 3. The Bidder's software programmer(s) shall hold a valid credential of "Crestron Certified Master Programmer" as licensed by the Crestron Technical Institute (CTI).
 4. The Bidder shall clearly identify project team members (Installers) pertaining to the installation of AV systems.
 5. Team members to be identified shall be Principal, Project Manager, Chief Engineer, Senior Field Technician, and Software Programmer.
 6. The documentation shall include the individual's certification
 7. Due to the complexity of the control & automation system, a manufacturer-certified software programmer shall be required to author the programming component of this project.
 8. The Contractor shall include in the Bid Response, the name and office location of the manufacturer certified person or entity that will provide programming for the remote control system. Copies of the programmer's certification shall be included in the bid.
 9. A list of equipment manufacturer product lines, relevant to the project, for which the Contractor is authorized as a Distributor, Dealer, and Installer.
 10. A list of equipment manufacturer product lines, relevant to the project, for which the Contractor is authorized to provide warranty repair service.
- B. All provided Installer and Programmer Qualifications (listed above) shall be current and valid at the time of bidding. For example, the Contractor shall not list a product manufacturer or line for which he/she is not a dealer on the bid due date, but for which he/she hopes or intends to become a dealer in the future.
- C. Source Limitations: Obtain common materials and equipment through one source from a single manufacturer as much as practical.
- D. All equipment for this installation shall be new (packaged in the manufacturer's original packaging), less than one year from the date of manufacture, and without blemish or defect.
- E. The Contractor shall maintain the same project manager and field supervisor throughout the installation, and will maintain the same installers.

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- F. The Contractor shall supply and install any incidental equipment needed in order to result in a complete and operable system without claim for additional payment, even if such equipment is not listed in this Specification.
- G. All work related to this Specification shall be completed in a professional manner by fully qualified workers.
- H. Reliability: The systems shall be designed to provide professional quality operation over a period of several years without the need for continual maintenance. Equipment that has a high failure rate is not acceptable for installation as part of these systems.
- I. Pre-installation meeting: Conduct pre-installation meeting with other trades to:
 - 1. Verify project requirements and manufacturers' instructions
 - 2. Coordinate environmental conditioning of the space (temperature & humidity)
 - 3. Coordinate elements attaching to, penetrating through, or concealed above/behind work in this section.
- J. 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.
- K. Comply with NFPA 70, "National Electrical Code."

1.10 DELIVERY, STORAGE, AND HANDLING

- A. Equipment, Cabling and Installation Materials:
 - 1. Costs of all shipping to the site, and of all unusual storage requirements, shall be borne by the Contractor.
 - 2. It shall be the responsibility of the Contractor to make appropriate arrangements, and to coordinate with the authorized personnel at the site, for the proper acceptance, handling, protections, and storage of equipment so delivered.
 - 3. If containers are used open each container; verify contents against packing list, and file copy of packing list, complete with container identification for inclusion in operation and maintenance data.
 - 4. Save original manufacturer's containers and packing materials and deliver as directed under provisions covering extra materials.
 - 5. Save all packing slips.
 - 6. Waste Management and Disposal: Separate waste materials for recycling in accordance with Division 01, Section "Construction Waste Management and Disposal".
 - a. Remove packaging materials from site and dispose of at appropriate recycling facilities.
 - b. Collect and separate for disposal paper, plastic, corrugated cardboard and/or polystyrene packaging materials in appropriate onsite bins for recycling.

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- c. Dispose of all non-recyclable packaging materials and debris in a safe and environmentally responsible manner according to the instructions set forth by the General Contractor, local ordinances or codes and the Environmental Protection Agency.

1.11 PROJECT CONDITIONS

- A. Environmental Conditions: System shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:
- B. Interior, Controlled Environment: System components installed in temperature-controlled interior environments shall be rated for continuous operation in ambient conditions of 36 to 122 deg F (2 to 50 deg C) and 20 to 90 percent relative humidity.

1.12 WARRANTY

- A. Project Warranty: Refer to Contract Conditions for project warranty provisions.
- B. Manufacturer Warranties: Submit to Owner or Owner's Representative all written and dated warranties, in addition to completed product support registration cards, as issued by product manufacturers warranting all individual components against defects in materials or manufacturing, for the periods established by said manufacturers. The start date of the warranties shall be the date of shipment from the manufacture.
 - 1. A report shall be made that lists Manufacture, model number, serial number, date purchased and the manufactures warranty time.
- C. System Warranty: The Bidding Contractor or sub-contractor (Installer) shall make known, in writing, at time of Bid any exceptions that might exist between conditions described herein and Installer's policy of warranty. After acceptance of bid, all conditions and requirements of warranty described herein shall apply.
 - 1. For material that carries less than a 1 year warranty shall be documented by the contractor and that document included in the close out documents for the owner and designer.
- D. Equipment that the Installer does not provide as part of this contract is exempt from this warranty coverage. However, the installation labor and materials associated with any equipment installed by the Installer, including OFCI items, shall be covered under this warranty.
- E. During the warranty period, within 24 hours of notification, the Installer shall answer all service calls and requests for information.
- F. During the warranty period, within 72 hours of original notification, the Installer shall provide emergency service to restore operation of the system, replacing defective materials, repairing faulty workmanship, making temporary repairs, and providing loaner equipment as necessary, all at no charge.
- G. The Installer shall notify the Owner of any service call or work to be performed for which charges may be incurred before such work commences. The Owner may be billed for non-warranty calls.

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- H. Improper functioning, for warranty purposes, means failure of the system to meet the intentions of the specification because of internal defects.
- I. It does not include Owner-caused malfunctions such as re-adjustment of the controls, re-tuning of the system, or injury to the system beyond normal wear.
- J. Nor does the warranty cover paint, exterior finishes, fuses, lamps (including projection lamps) or associated labor, unless the damage or failure results from defective materials or workmanship covered by the warranty.
- K. The Installer shall take such actions at the time of installation to ensure that all equipment is installed in accordance with the manufacturer recommended environmental and electrical operating conditions and requirements.
- L. After installation, the Installer shall be responsible for the repair or replacement of said equipment that the Installer provided which fails due to environmental or electrical conditions, even if not covered by the manufacturer's warranty.
- M. The Installer shall not be held responsible for damages due to changes in environmental conditions which occur after system acceptance.
- N. If the Installer has modified certain components, the manufacturer's warranty for such components may become void. In such a case, the Installer is responsible for providing warranty coverage equal to that originally provided by the manufacturer.
- O. Certain subsystems and system components may require installation by authorized representatives in order for the complete manufacturer warranty to apply. If this pertains to any subsystem or component for this project, it is the Installer's responsibility to make arrangements for the complete manufacturer warranty to apply. These arrangements are to be made at no additional cost to the Owner.

1.13 SERVICE CONTRACT

- A. As part of this Specification, the Contractor shall initiate a one-year service contract to commence on the date of final acceptance and continue to the first anniversary of the date of final acceptance as defined in 'System Acceptance'. The scope of the service contract would normally extend beyond warranty service calls, to include ongoing support of the AV systems such as maintenance, periodic replacement of consumables, Owner training or assistance, and/or additional design-build agreements.
- B. As part of the Bid Response, the Contractor shall provide the Owner with a proposal for continuation of the service contract to include Year Two (2), Year Three (3), Year Four (4) and Year Five (5) of operation. All terms and conditions of the Year One Warranty shall apply.

1.14 PRIOR APPROVAL

- A. For substitutions of products specified herein, Contractor shall submit requests for prior approval at least 10 days prior to submitting bids, and in accordance with the provisions of Bidding Instructions and/or Division 1.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Provide products quantities as required. If a quantity is given, provide at least the given amount.
- B. Products shall be new, free from defects and listed by UL when an applicable UL Standard exists. Provide Products of a given type from one manufacturer.
- C. Regardless of the length or completeness of the descriptive paragraph under article titled "Manufacturers and Products", provide Products complying with the specified manufacturer's published specifications.
- D. Take care during installation to prevent scratches, dents, chips, etc.

2.2 MANUFACTURERS AND PRODUCTS

- A. If a specified product has been discontinued by a manufacturer, and cannot be repaired by the manufacture during the warranty period. Than the contractor need to provide a replacement model (as certified by the manufacturer) Than any price difference should be discussed with the owner and once approved can be billed back to the owner
- B. Where required provide manufacturer's rack mount adapter or one manufactured by Middle Atlantic or other rack accessories manufacture.
- C. Provide complete and fully functional systems, including items that are not explicitly described herein, but are necessary for a complete functioning system which shall adhere to the performance parameters as described on the drawings and/or required by these specifications. Items shall include, but are not limited to, all required mounting hardware and faceplates.

2.3 SOFTWARE

- A. All commercial software used, shall be registered to Owner, in Owner's name. Owner to be supplied with all software documentation including copies of software registration.
- B. Contractor shall load and test the required software on an Owner furnished computer and load and test all required updates to control panels. Provide a complete and fully functional network management system.
- C. Contractor shall provide all non-compiled programs including all macros, custom drivers as well as the compiled software on a flash drive (USB Stick). This includes controller, Touch panel, DSP's and other items that require programming.
- D. Coordinate all management, control and monitoring functions with the Owner. Minimum requirements shall include:
 - 1. Event scheduling
 - 2. System control of individual systems

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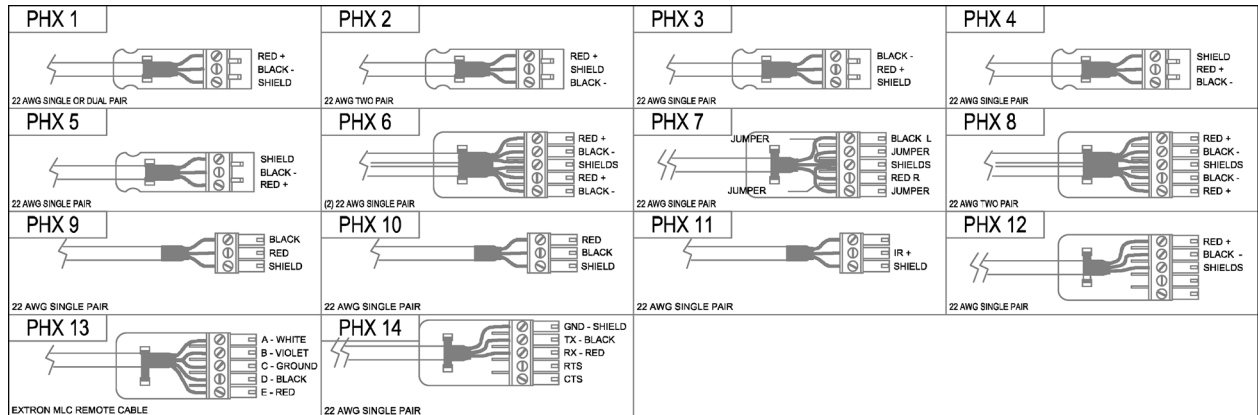
2.4 MULTI-MEDIA SYSTEMS

- A. Provide product makes and models as listed in APPENDIX A attached to the end of this Section.
 - 1. Provide complete and fully functional systems, including items that are not explicitly described herein, but are necessary for a complete functioning system which shall adhere to the performance parameters as described on the drawings and/or required by these specifications. Items shall include, but are not limited to, all required mounting hardware and faceplates.

2.5 CABLING

- A. Color code for Category 6A will be shielded yellow. This will be used for all digital video equipment
 - 1. Green non shielded Category 6 or 6A will be used for all control of the system
 - 2. Orange shielded Category 6 or 6A will be used for misc. equipment i.e. usb extenders, etc.
 - 3. Purple Shielded cat 6/6A for Dante and audio
- B. Any Category Cabling that does not go to a wall plates or items such as the Touch Panel, interconnect cabling will be flexible so as not to kink knot up.
- C. Pre made cabling is recommended for internal rack work & connection for touch panel, usb, and other outboard equipment at the discretion of the contractor
- D. Connection for touch panels shall terminate on a Red RJ 45 in a single input biscuit box.
- E. PIN OUT DIAGRAMS

PIN-OUT



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XLR M 1 - SHIELD 2 - RED + 3 - BLACK - 22 AWG SINGLE PAIR	XLR F 1 - SHIELD 2 - RED + 3 - BLACK - 22 AWG SINGLE PAIR	XLR5M 1 - WHITE + 2 - GREEN - 3 - SHIELD 4 - RED + 5 - BLACK - 22 AWG TWO PAIR	XLR5F 1 - WHITE + 2 - GREEN - 3 - SHIELD 4 - RED + 5 - BLACK - 22 AWG TWO PAIR
XLR6M 1 - RED 2 - BLACK 3 - SHIELD 4 - NIC 5 - NIC 6 - NIC CAT5 / CAT6	XLR6F 1 - RED 2 - BLACK 3 - SHIELD 4 - NIC 5 - NIC 6 - NIC CAT5 / CAT6		
RCA BLACK & SHIELD RED 22 AWG SINGLE PAIR	TRS BLACK SHIELD RED 22 AWG SINGLE PAIR	3.5MM BLACK SHIELD RED 22 AWG SINGLE PAIR	NL4 4 POLE SPEAKON RED + BLACK - 12 - 16 AWG SPEAKER
SPK 1 RED + BLACK - 16 AWG SPEAKER	SPK 2 BLACK - RED + 16 AWG SPEAKER	SPK 3 LEFT SPEAKER RIGHT SPEAKER BLACK - RED + RED + BLACK - 16 AWG SPEAKER	SPK 4 RED + BLACK - 18 AWG SPEAKER
SPK 5 SPEAKER LOOP SPEAKER IN LOOP THRU RED - IN RED + IN BLACK - LOOP THRU BLACK - 16 AWG SPEAKER	SPK 6 IN FROM AMP PARALLEL OUT +1 +2 -3 -4 14 AWG SPEAKER	SPK 7 100V - NC / 1W / 2W / 4W / 8W / 16W / 30W 70V - COM / 100W / 8W / 4W / 2W / 1W / NC BLACK RED 18 AWG SPEAKER	
RJ45A GREEN WHITE ORANGE WHITE BLUE WHITE BLUE ORANGE BROWN WHITE BROWN CAT5 / CAT6	RJ45B ORANGE WHITE ORANGE GREEN WHITE BLUE BLUE WHITE GREEN BROWN WHITE BROWN CAT5 / CAT6	RJ11C 1 - 24V 2 - Y 3 - Z 4 - GRD CAT5 / CAT6	RJ14 1 - COM 2 - DOWN 3 - UP CAT5 / CAT6
DMNET D - RJ45B M - RJ45B CNET CRESTRON DM-CBL-P			
DB9M 1 SHIELD RED BLACK 22 AWG SINGLE PAIR	DB9F 1 BLACK RED SHIELD 22 AWG SINGLE PAIR	DB9M 3 TANDBERG / CISCO CAMERA CONTROL BROWN WHITE & ORANGE ORANGE WHITE & BROWN BLUE GREEN WHITE GROUND +12V Rx Tx CAT5 / CAT6 RJ45B AT CAMERA	
RELAY JUMPER UP - RED COMMON - SHIELD STOP - BLACK COMMON - SHIELD 22 AWG SINGLE PAIR	RELAY2 1 - RED 2 - BLACK G - SHIELD 22 AWG SINGLE PAIR		
CNET SHIELD RED + 24V WHITE - Y GREEN - Z BLACK - GRD CRESTNET	IR IR + BLACK 22 AWG SINGLE PAIR	I/O RED SHIELD 1 2 3 4 5 6 7 8 22 AWG TWO PAIR	RBUS RED + BLACK - WHITE - HI GREEN - LO SHIELD 22 AWG TWO PAIR
DALITE UP - RED DOWN - BLACK COMMON - SHIELD BUS 5V CAT5 / CAT6		PWR 1 RED + BLACK - 18 AWG SINGLE PAIR	

2.6 PRODUCT SUBSTITUTIONS

- A. Refer to "Prior Approval" in Part 1 of this document.
- B. The materials and products specified herein reflect the minimum acceptable standards of fabrication and manufacture. All materials and products supplied by the Contractor and specified herein are to be new, unused, of first quality and in original packaging or shipping containers or as shown on drawings.

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- C. The products listed herein are pre-approved for this project. Substitutions shall be permitted for the manufacturers and products contained herein, provided they equal or exceed the specifications thereof and are approved via formal request.

2.7 SURGE PROTECTION AND POWER

- A. Surge Protection: Protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads. Include surge protection for external wiring of each conductor-entry connection to components.
- B. Minimum Protection for Power Connections 120 V and More: Auxiliary panel suppressors complying with requirements in Division 26 Section "Transient-Voltage Suppression for Low-Voltage Electrical Power Circuits."
- C. Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Connections: Comply with requirements in Division 26 Section "Transient-Voltage Suppression for Low-Voltage Electrical Power Circuits" as recommended by manufacturer for type of line being protected.
- D. Refer to the NEC handbook article 380 as it refers to power strips (Multiple output)

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine pathway elements intended for cables. Check raceways, cable trays, and other elements for compliance with space allocations, installation tolerances, hazards to cable installation, and other conditions affecting installation.
- B. Examine roughing-in for LAN and control cable conduit systems to AV equipment, PCs, speakers, microphones and other cable-connected devices to verify actual locations of conduit and back boxes before device installation.
- C. Cable labeling will be 6" back from cables connector.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Comply with EIA/TIA-606, "Administration Standard for the Telecommunications Infrastructure of Commercial Buildings."
- B. In meetings with Architect and Owner, present Project planning documents and review, adjust, and prepare final setup documents. Use final documents to set up system software.

3.3 GENERAL INSTALLATION PRACTICES

- A. All equipment with the exception of portable equipment shall be firmly fastened or attached in place. A safety factor of at least four shall be utilized for all brackets, fasteners and attachments.
- B. In the installation of equipment and cable, consideration shall be given not only to operational efficiency, but also to overall aesthetic factors.
- C. The Contractor shall insure that all equipment is installed such that proper cooling and ventilation is insured.
- D. All equipment shall be installed in a manner, which prevents hum, RF/EMI/EMF interference, and mechanical vibration based noises (e.g. fan mounts, etc.)
- E. All equipment and furniture shall be protected from construction dust and debris until final acceptance of the system.
- F. All equipment shall be protected from theft until final acceptance of the system.
- G. The Contractor shall be under obligation to protect completed work and uncompleted work against damage or loss until the Owner has given final acceptance. Should the need arise to repair work or replace items. The Contractor shall do so at no cost to the Owner.

3.4 FURNITURE

- A. The Contractor shall ensure that equipment or mounting hardware is compatible with and suitable for installation in furniture specified by the Architect, Consultant, or Furniture Supplier. It shall further be the Contractor's responsibility to ensure that such coordination with the Architect, Consultant, or Furniture Supplier occurs. The Contractor shall exchange with and follow such Shop Drawings as to ensure that dimensions and structural supports are adequate for the installation of specified equipment. It is the Contractor's responsibility that the request and delivery of such critical coordination information is satisfactorily executed. Inasmuch as the Contractor has control over the delivery of such information, he shall deliver it as requested by the Architect, Consultant, or Furniture Supplier.

3.5 EQUIPMENT RACKS AND CABLE MANAGEMENT

- A. Use tamper-resistant Torx security type mounting screws for all rack-mounted A/V equipment. The owner will receive 3 additional Torx blades top allow the owner to have the ability to remove equipment.
- B. Racks shall be installed in such a way as to permit access to all equipment for service.
- C. All equipment in racks shall be fitted with vent panels and/or fans as required to provide ventilation and cooling according to equipment manufacturer's recommendations. Fans should be ultra-quiet and able to move 120 CFM, have a noise level of no more than 24 DB and dual ball bearings. Fan guards will be used if the fan has an open front or rear for safety.
 - 1. The fan can be AC or USB powered. It will have a thermostat to set the temperature of the rack-furniture.

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2. Blank rack spaces will have a blank panel put in.
 3. If possible a 2 RU locking drawer shall be used for holding mics, remotes for the equipment and other items that are used for video presentations.
- D. Adjacent racks shall be bolted together with appropriate ganging hardware.
- E. As a general practice, all power cables, control cables, and high-level cables shall be dressed to the left rear of an equipment rack. Audio and video cables shall be dressed to the right rear of the rack. Audio, video and control cables shall be bundled separately and spaced not less than three (3) inches apart.
- F. Internal equipment rack cabling shall be supported by lacing strips, support brackets, or other cable management systems as required to ensure that all cabling is supported in both the vertical and horizontal planes within the rack.
- G. With the exception of ganged equipment rack assemblies, cabling routed between equipment racks or pieces of equipment exterior to equipment racks, or extending to the greater facility cabling infrastructure, shall be completely protected, end-to-end, by a raceway, wire-way, or duct appropriately sized for the cable run.
- H. Cabling between rolling pieces of equipment not housed in rack cabinets or a split-loom corrugated tubing wrap or other such flexible cable management system appropriately sized for the cable run shall protect a rolling equipment rack and any device to which it is connected.
- I. Any controls not to be adjusted by the user and accessible from the front of the equipment rack must be furnished with security panels.
- J. 1 RU Rack shelves or specific rack mounts specific to that piece of equipment should be used to hold accessory equipment such as power supplies, extenders converters etc. No equipment should be attached or stacked on another piece of rack mounted equipment.
- K. UL Listing: Rack system shall be UL Listed in the US and Canada.

3.6 GROUNDING

- A. Comply with Division 26 Section "Grounding and Bonding for Electrical Systems."
- B. Comply with IEEE 1100, "Power and Grounding Sensitive Electronic Equipment."
- C. Ground cable shields, drain conductors, and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
- D. Bond shields and drain conductors to ground at only one point in each circuit.

3.7 IDENTIFICATION

- A. All equipment components will be identified with a unique, permanently affixed laser-engraved label. Provide a schedule or database of labels and identifiers to Owner at completion of project installation.

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- B. Information on the label will be where the cable connects to I.E HDMI DA (Output Number) and where it terminates. (DMPS-4k-350 (Input Number)
- C. The label material should high adhesion self-laminating vinyl wire wraps.
- D. Labels are applied 6” from the connector on the source and destination side of the cable.
- E. At completion, all labels and schedules shall reflect as-built conditions.
- F. All pieces that have a IP address associated with it will have a printed label on the front and back with that IP address.

3.8 FIELD QUALITY CONTROL

- A. **Manufacturer Field Service:** Where required by equipment manufacturer, engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including connections. Report results in writing.
- B. **System Set-up and Tuning**
 - 1. **Optimization:** The Contractor shall install, configure, adjust, program, and calibrate all components in order to optimize the performance of all individual subsystems and the system as a whole.
- C. **Preliminary Tests:**
 - 1. **General:** Once the system is installed, the Contractor shall complete the following preliminary tests and prepare a written test report for the Consultant. The test report will list the results of each of the tests described in this section and certify that the installation is complete.
 - 2. **Control:** Upon completion of installation, the Contractor shall test each function of each control station, push-button panel, touch screen panel, computer control interface, and all components connected to or interfaced to the Control System to verify proper operation and that each switch and indicator operates as intended.
 - 3. **Audio:** The Contractor shall perform the following tests:
 - a. Prior to the termination of audio amplifiers to speakers, the Contractor shall measure the resistance of the speaker line with reference to ground to determine that no short circuits or paths to ground exist in the line. The Contractor shall connect the speaker to the cable and measure the impedance of each speaker line using a 1,000Hz signal applied to the line. The Contractor shall submit a list, to the Consultant, by cable number, of the impedance of each speaker line. This test shall be performed with the amplifier disconnected from the speaker line and the speaker connected to the speaker line.
 - b. Verify all loudspeakers are functioning.
 - c. Verify that the system meets all Performance Requirements as outlined in this section.
 - d. Verify that all equipment, panels, and cables are labeled correctly.
 - e. Verify each item of equipment is functioning as intended.

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- f. Verify the installation is the same as specified.
- D. Video: To establish that the facility cabling and terminations meet the specifications necessary for proper functioning of the overall system, a video test signal shall be applied to each input cable and passed through the system switching and distribution networks with the results measured at each system output.
1. In addition, the Contractor shall:
 - a. Verify each item of equipment is functioning as intended.
 - b. Verify the installation is the same as specified.
 2. Computer Video Display Devices: The Contractor shall use a computer-video test generator to establish that computer video capable displays such as LCD, flat panel, and projection devices are in good working order and optimally adjusted. The computer-video test generator shall be capable of outputting test signals on HDMI and VGA connectors. The computer-video test generator shall meet or exceed the following specifications and offer the following test patterns:
 3. Analog Specifications:
 - a. Bandwidth: 450 MHz (VGA)
 - b. Dot clock: 230 MHz
 - c. Pixel clock accuracy: 0.02 MHz
 - d. Scan rate accuracy: +/- 2%
 - e. Frequency range: 15kHz to 127 kHz
 - f. Rise/fall time: < 1.2nS
 - g. Signal types: RGBHV
 - h. Maximum level: 1V p-p
 - i. Impedance: 75 ohms
 - j. Return loss: -30db @ 5MHz
 - k. DC offset: +/- 5mV maximum
 - l. Digital Specifications:
 - m. Ability to generate 1080P, 1080I, 720P, 2 K , 4K
 - n. Color Spaces: RGB, YCbCr (4:4:4, 4:2:2, 4:2:0)
 - o. Color Depth: 8-bit through 16-bit
 - p. HDMI Standard: HDMI 2.0. 2.2 (a)
 - q. Content Protection Standards: HDCP (1.4, 2.2)
 - r. EDID Information
 - s. Audio-
 - t. 4 independent audio channels (2 stereo pairs) each with adjustable level and frequency
 - u. Preset frequency selections 50/100/200/250/400/800 HZ,

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v. Audio sweep test 20 khz to 20 Hz

E. Digital Test Generator:

1. The portable HDMI Signal Generator & Analyzer provides a convenient way to test and verify all aspects of an HDMI signal path, including source and sink. This unit complies with the HDMI 2.0a and HDCP 1.4/2.2 standards. The unit's Analyzer mode complies with the CEA standard HDR static metadata extensions CEA-861-F and CEA-861.3 for EDID analysis. Battery operation is recommended. Output resolutions should SDTV to 8K.
2. Test Patterns:
 - a. Pal-NTSC Color Bars
 - b. SMPTE Color Bars Used to Evaluate and adjust color decoder on the display. This also has the plunge pattern
 - c. Full Field Red
 - d. Full Field Green
 - e. Full Field Blue
 - f. Full Field Back
 - g. Full Field White
 - h. 8 Step Gray Scale
 - i. 16 Step Gray Scale Used to evaluate and adjust gray scale tracking If some are missing check the displays white, black level and gamma.
 - j. Vertical Split Used to measure contrast ratio, luminance of white
 - k. White Screen This pattern can be used for screen uniformity, peak luminance or white
 - l. Crosshatch,
 - m. Multiburst Vertical This is a resolution test to adjust sharpness and scaling capabilities of display
 - n. Moving Ball used to judge motion.
 - o. Alternate W.B. This pattern alternates between full field white than black. Used to test or analyze the backlight of an LCD Panel
 - p. Line V Scroll Used to check motion. The line should move across the screen smoothly and not choppy
 - q. Line H Scroll Used to check motion. The line should move across the screen smoothly and not choppy
 - r. Final Tests
 - s. Upon approval of the Contractor's test report, and at a time that is mutually acceptable to the Contractor, Owner and Consultant, the Contractor shall assist the Consultant and Owner in final system tests and adjustments. The Contractor shall allow one (1) day to perform the tests. The Contractor's representatives assisting in the performance of these tests shall be thoroughly familiar with the details of the system and shall include the field supervisor responsible for installing the system.

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- t. To demonstrate the good working order of all playback devices in the system the Contractor shall make available high quality source materials for all audio and video media types represented in the system. To demonstrate the good working order of all computer-video displays the Contractor shall make available the computer-video signal generator described in 'Performance Standards – Preliminary Tests and Submittals – Computer Video Display Devices'. In addition, the Contractor shall make available a laptop computer with the ability to output:
- 3. Standard Definition television (SDTV)
 - a. 480I (NTSC Composite)
 - b. 576i (PAL compatible)
- 4. Enhanced definition television (EDTV)
 - a. 480 P (720 X 480 progressive scan)
 - b. 576P (720 X 576 progressive scan)
- 5. High Definition Television (HDTV)
 - a. 720 P (1280 X 720 progressive Scan)
 - b. 1080i (1920 X 1080)
 - c. 1080P (1920 X 1280 progressive scan)
 - d. 1366 X 768 HD
- 6. Ultra High definition television
 - a. 2K (1920 X 1080P progressive scan)
 - b. 4K UHD (3840 X 2160 Progressive scan)
 - c. 8K UHD (7680 X 4320 progressive scan)
- F. Graphics with at least 16bit color depth. The computer shall be capable of displaying spreadsheets, graphs, charts, pictures and text of varying sizes and fonts to effectively demonstrate the systems computer display imaging capabilities.
- G. The Contractor shall demonstrate operation of all subsystems, including audio and video recording, displays, cameras, camera controls, streaming, and control system and so on, meets or exceeds the criteria as outlined in this section.
- H. Remove and replace malfunctioning devices and circuits and retest as specified above.

3.9 STARTUP SERVICE

- A. Engage a factory-authorized service representative as needed, to supervise and assist with startup service as needed. Complete installation and startup checks according to approved procedures and with manufacturer's written instructions.

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3.10 PROTECTION

- A. Maintain strict security during the installation of equipment and software. Rooms housing the AV components that have been powered up shall be locked and secured, with an activated access-control system or keyed system during periods when a qualified operator in the employ of Contractor is not present.

3.11 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain AV system. Refer to Division 01 Section "Demonstration and Training."
- B. The Contractor shall provide a total of four (4) hours of on-site training for the Owner's staff at a time that is mutually agreeable for the Owner and Contractor. The Contractor should anticipate three sessions of the following lengths: two (2) "basic" sessions of one hour each, and one (1) "advanced" session of two hours. The Owner may choose to have the sessions spread out over a maximum of three different days. Final acceptance and/or final payment for the system shall not be delayed due to scheduling delays beyond the control of the Contractor.
- C. In addition, the Contractor is responsible for scheduling and coordinating the specified manufacturer training with the Owner.

3.12 SYSTEM ACCEPTANCE

- A. Upon successful completion of Final Tests, Documentation and Training, the Contractor shall notify the Owner, in writing, that the system is complete. The Owner shall have twenty-one (21) days to generate a "punch list" of omissions, adjustments, corrections and the like and respond in writing to the Contractor. In the absence of such a "Punch List," the system shall be considered to be complete. The warranty shall commence on the twenty-first day after the Contractor's notification of completion of work, and the Owner shall process final payment. In the event that further work is required to complete this project, the Contractor shall be prepared to continue work, without additional compensation, until the system is accepted.

END OF SECTION

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APPENDIX A: BASIS OF DESIGN SYSTEM CONFIGURATION

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APPENDIX A: Specified Basis-of-Design Materials List			
	<p>NOTE: THIS LIST CONSTITUTES THE EQUIPMENT USED IN THE "<u>BASIS OF DESIGN</u>" FOR THE AUDIO-VISUAL SYSTEM. UNDER NO CIRCUMSTANCES SHALL THIS EQUIPMENT LIST BE TAKEN AS A COMPREHENSIVE LISTING OF ALL EQUIPMENT REQUIRED FOR A COMPLETE AND FUNCTIONAL SYSTEM AS SPECIFIED. CONTRACTOR IS RESPONSIBLE FOR PERFORMING THEIR OWN EQUIPMENT TAKE-OFFS AND VERIFYING ALL REQUIRED EQUIPMENT AND MATERIALS ARE PROVIDED.</p>		
	1. Provide all necessary materials, turn-key installation, testing, and commissioning.		
	2. Provide all necessary software programming for automation control system, audio DSP, etc.		
	3. Provide end-user training as specified within these specifications.		
	4. The specific system configurations are listed in the following table. Each 'system type' includes a list of key components & instructions which is intended to serve as the basis-of-design / proof-of-concept; however these lists may not be comprehensive of all required materials, cabling, hardware etc. The contractor shall verify all specified components and instructions for compatibility with the intended functionality of the specified A/V systems – and provide additional materials etc. as required to perform the work – for turn-key installation of these systems.		
Ref #	Item / Description	Baseline Make / Model	Unit Qty
<i>LOBBY DIGITAL SIGNAGE -[Beginning]</i>			
	<i>Display System:</i>		
1	55 inch Direct Backlight, native resolution, Aspect 16:9, Brightness 400 nits, contrast ratio 1200-:1, response time 8 ms, viewing angle 178 degrees X 178 degrees	LG, NEC, Samsung, Sony, Sharp or equivalent	1
2	Universal Micro-Adjustable Tilting Wall Mounting Bracket & Hardware for Large Flat Panel Displays, Compatible with 50+" Displays, +/-12 degrees of Tilt, 200lb Capacity, Post-Install Height and Centering Adjustment, Black Color	Chief LTA1U	1
<i>Meeting Rooms 108, 172, 146 - [Beginning]</i>			

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3	<p>75" LED Display 120 VAC, 50 / 60 Hz Power Consumption Typical: 115.0 W Standby: < 0.5 W, Weight 37 lb / 16.8 kg (With Stand) 32.6 lb / 14.8 kg (Without Stand) DISPLAY 4K UHD 3840 x 2160 OLED Evo Panel HDR10, HLG, Dolby Vision Compatible webOS 22 with LG ThinQ AI ALLM, FreeSync Premium, VRR, G-SYNC 120 Hz Refresh Rate Built-In Wi-Fi & Ethernet Connectivity 4x HDMI 2.1 Inputs Includes Voice Remote Control Auto Low Latency Mode (ALLM) Yes Bit Depth / Color Support 10-Bit (1.07 Billion Colors) Size 64.5" Panel Type OLED Aspect Ratio 16:9 Display Orientation Landscape Resolution 3840 x 2160 HDR Compatibility HDR10, Dolby Vision, Audio Return Channel (ARC) eARC HDCP Support Version 2.2 Output Ports 1 x TOSLINK Optical (Digital Audio) (Side) Ethernet LAN Input Ports 4 x HDMI Type A (HDMI 2.1) (Side) 1 x Coaxial F-Type (RF Antenna) (Side) Control RS-232C via 1/8" / 3.5 mm Input</p>	<p>Sony , Samsung, NEC, LG, Sharp, Optoma</p>	3
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4	Universal Micro-Adjustable Tilting Wall Mounting Bracket & Hardware for Large Flat Panel Displays, Compatible with 50+" Displays, +/-12 degrees of Tilt, 200lb Capacity, Post-Install Height and Centering Adjustment, Black Color	Chief LTM1U	3
5	Conferencing Solution for Small Meetings. UHD 4K Video Capture with 120° FOV. 6-Element Mic with 12' Pickup Range. Acoustic Clarity Technology. Acoustic Fence. designed as an efficient video conferencing solution for small meeting rooms. Via a simple USB interface, it can quickly be set up with any application that supports standard USB video and audio drivers, including popular platforms such as Teams, Zoom, and Skype for Business.	Polycom Studio USB Video Bar 7200-85830-001 Or Equivalent	3
BYOD			
6	The WAVE-101's Wi-Fi wireless BYOD interfacing is simply enabled through the device's native casting protocol (including AirPlay, Google Cast, or Miracast). It allows for screen mirroring from up to four devices without the need to install an app. The unit can serve as an integrated, dual-band access point or it can be networked into an existing Wi-Fi installation. In addition, the WAVE-101 supports Miracast over Infrastructure, which allows Miracast over a facility Wi-Fi network or LAN rather than over a direct wireless.	Atlona Wave 101	3
Control			

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7	<p>Manage, monitor, and control AV devices using a standard Ethernet network. Two bidirectional RS-232 ports — Captive screw serial ports that can communicate with two RS-232 serially controlled devices. Two bidirectional RS-232 ports — Captive screw serial ports Two relays for controlling room functions — Enables control of lighting, screen settings, and other device functions. One IR port for connecting up to two emitters — For one-way control of external devices. Volume control knob with LEDs for visual feedback — Control the volume of a device with RS-232, Ethernet, or IR; or remotely control the volume of Extron MPA and select XTRA™ Series amplifiers via the remote volume control port. Power over Ethernet allows the controller to receive power and communication over a single Ethernet cable, eliminating the need for a local power supply. Supports Ethernet-controllable devices. Removable captive screw connectors — Provides quick and easy connection to the controller for easy installation and troubleshooting. Configurable buttons — Can be set up to control display power, input selection, volume, or any other IR/RS-232 command supported by the display. Dual color, field-labelable, backlit buttons — Buttons illuminate red or white for ease of use in low-light environments. Pre-printed label sheets are included. Removable button caps — Make it easy to label each button to clearly indicate its function. Labels can be quickly changed in the field and don't require programming or engraving.</p>	Extron MLC Plus 200	3
	<i>AV Transport System:</i>		

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8	HDMI Over Twisted-Pair Receiver	DTP HDMI 4K 230 Rx	3
9	HDMI Over Twisted-Pair Wall Plate 700Transmitter	DTP T HWP 4K 231 D	3
		Total Meeting Rooms	
Large Conference Room 102 and 103			
	Display System:		
10	<p>86" Commercial QLED display. Also, if there is no input signal, it is possible to show the content preset by the user instead of the conventional "No Signal" message.</p> <p>Compatibility with AV Control Systems</p> <p>The UR340C series has been certified Crestron Connected, which means it has a high level of compatibility with professional AV controls. This results in virtually seamless integration and automated control, boosting business management efficiency.</p> <p>USB Auto Playback</p> <p>USB data cloning makes managing multiple displays efficient for optimal operation. Instead of setting up each display one by one, data can be copied to a USB drive for one display, and then that data will be sent to the other displays through a USB plug-in.</p> <p>DPM (Display Power Management)</p> <p>DPM can be configured to be on only when there is a TV signal present to manage power more efficiently.</p>	LG, NEC, Samsung, Sony, Sharp or equivalent	4
11	Universal Micro-Adjustable Tilting Wall Mounting Bracket & Hardware for Large Flat Panel Displays, Compatible with 50+" Displays, +/-12 degrees of Tilt, 200lb Capacity, Post-Install Height and Centering Adjustment, Black Color	Chief LTM1U	2

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12	<p>The PNR is wall-mounted, rugged, versatile, and installer-friendly. The PNR is compatible with the standard (14" x 14") PSB interface bracket in which a display can be mounted in either the landscape or portrait position on the PNR. The dual arms on the PNR: Extend from the wall 25" in length Pivot up to 90° left or right of center The standard PNR is shipped with the support posts for the dual arms centered in the mount. The support posts can be moved laterally right or left of center to readily accommodate sites with limited wall space. The mount also has over an inch of height adjustment. The tilt range for the display is 5° up and 15° down. T</p>	Chief PN-RUB 27	2
AV Transport			
13	<p><u>With a ZyPerUHD, you can easily distribute video up to 4K from any source to an unlimited number of displays directly over a standard Gigabit network switch. Using industry-standard CatX cables, you can send audio and video from any HDMI source up to 100 meters away with a clear picture. Each source with a ZyPerUHD can send HDCP copy-protected HDMI signals to one or multiple displays without any loss of frames. ZyPerUHD uses compression and can distribute video, digital audio, and control signals all over standard networking cables and network switches - eliminating the need for a traditional dedicated AV matrix switcher. JPEG 2000 COMPRESSED 4K VIDEO, AUDIO, AND CONTROL USING OFF-THE-SHELF</u></p>	ZyZYPERUHD-D Decoder	4

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14	<p><u>ZyPerUHD Wallplate Encoder</u> <u>ZyPerUHD Wallplate Encoder is a HDMI 2.0 and VGA input Encoder with IP streaming via Gbit/copper.</u> <u>Ports include: Audio Input of unbalanced stereo audio on 3.5mm jack, VGA video on 15-pin D-sub connector (no audio), HDMI 2.0a capable of up to 4KP60 4:2:0 with embedded audio and HDCP 2.2 encryption, IR, RS-232 control port and USB 2.0 Type B and POE. Includes wall mount brackets. Requires ZyPerUHD Decoder and ZyPerUHD management Platform. Cables not included.</u></p>	ZyPERUHD--WE Wallplate Encoder	11
15	<p><u>ZyPerUHD-E Encoder</u> <u>ZyPerUHD Encoder is a HDMI 2.0 a Encoder with IP streaming via Gbit/copper. Ports include: HDMI 2.0a capable of up to 4KP60 4:2:0 with embedded audio and HDCP 2.2 encryption, IR, RS-232 control port and USB 2.0 Type B and POE. Includes wall mount brackets. Requires ZyPerUHD Decoder and ZyPerUHD management Platform. Cables not included.</u></p>	ZyPerUHD-E Encoder	6
16	<p>ZeeVee’s acclaimed ZyPer Management Platform was designed around a single core concept — configure, not program. Balancing performance, core features, and an extended array of functionality, the ZyPer Management Platform enables AV over IP installations to be completed in hours, not days. Available in standard, enterprise, or VMWare configurations. Plug all the ZyPer encoders, decoders, and the ZyPer Management Platform (ZMP) into the same network and watch the magic happen. With zero-touch autodiscovery, the ZMP instantly recognizes all ZyPer appliances and makes them available to the MaestroZ user interface — no device configuration or programming required.</p>	ZHDMPUNL Management Platform	1

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	<i>BYOD</i>		
17	<p>Wi-Fi wireless BYOD interfacing is simply enabled through the device's native casting protocol (including AirPlay, Google Cast, or Miracast). It allows for screen mirroring from up to four devices without the need to install an app. The unit can serve as an integrated, dual-band access point or it can be networked into an existing Wi-Fi installation. In addition, the WAVE-101 supports Miracast over Infrastructure, which allows Miracast over a facility Wi-Fi network or LAN rather than over a direct wireless link. The system is equipped with a host of other convenient features for integrators and end users including programmable display control, a customizable welcome screen, storage and display of user-supplied static and video media, YouTube Live streaming, support for cloud-based digital signage applications, and more.</p>	Atlona ALT-ATWav101	2
	<i>Assistive Listening System (ALS):</i>		
18	<p>IR Assistive Listening System (ALS) with Rechargeable Receivers for ADA Compliance in Rooms Up to 50 People, Includes:</p> <ul style="list-style-type: none"> (1) IR Transmitter/Radiator w/ Mount (LT-84-01) (2) Portable DSP IR Receivers (LR-4200-IR) (2) Ear Speakers (LA-401) (2) Intelligent T-Coil Neck Loop Lanyard (LA-430) (1) 4-Port USB Charger (LA-423) (1) USB to Micro USB Cable (LA-422) (1) 75-Count Disinfecting Wipes (LA-901) (1) Notification Wall Placard / Sign (LA-303) 	Listen Technologies LS-90-01	2
19	Breakaway Neck Lanyard for ALS Receivers	Listen Technologies LPT-A207	2

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20	Wall Box Mounting Plate for IR Assistive Listening System Radiator, Attaches to 1-Gang Box, White Color	Listen Technologies LA-347	2
21	Power Supply Extender Kit for IR Assistive Listening System Radiator, Extends Power Connection Via CAT 5/6 Cable	Listen Technologies LPT-A117	1
	<i>A/V Control System:</i>		
22	The CP4N is a secure, high-performance control processor with a powerful 4-Series™ control engine. The CP4N is designed to integrate and automate technology within any modern networked home, commercial building, or government facility. An isolated control subnet port provides a Gigabit Ethernet LAN dedicated to Crestron devices.	Crestron CP 4N 6511817	1
23	Crestron 7" Touch Panrl	Crestron TS-770-B-S 6510820	2
	<i>Sound Reinforcement System:</i>		
24	The TesiraFORTÉ AVB VT4 is a digital audio server with 4 analog inputs and 4 analog outputs, and includes Acoustic Echo Cancellation (AEC) technology on all 4 inputs. It includes up to 8 channels of configurable USB audio, a 2-channel VoIP interface, and a standard FXO telephone interface. TesiraFORTÉ AVB VT4 utilizes AVB/TSN digital audio networking, and can be used as a standalone device or combined with other TesiraFORTÉ AVB devices and Tesira DSPs, expanders, endpoints, and controllers.	TesiraFORTE DAN VT DSP	1

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25	Stereo/parallel/bridge-mono mode • User-selectable input sensitivity to power consumer devices: 0.775V and 1.4V • RCA and XLR inputs; Speakon® and binding post outputs • Two level controls, power switch and LEDs to indicate signal presence, clip and fault for each channel • Protection against shorts, no-load, on/off thumps and radio-frequency interference. • Efficient forced-air cooling prevents excessive thermal buildup. One-year, no-fault, fully transferable warranty completely protects your investment	Crown xli800 Amplifier	2
26	Full-range ceiling tile speakers for 70/100 volt systems. They feature UL 2043 plenum rated enclosures that drop into suspended ceilings, resting directly on the T-bar support grid and replacing a portion of an existing ceiling tile. Designed with low profile enclosures, these speakers are an excellent choice for ceiling installations with tight above-the-ceiling space issues, such as air handling duct work installed close to the ceiling. The full-range driver features a wide frequency range of 68 Hz to 18 kHz, 16 watts continuous pink noise and 32 watts continuous program capacity. The FF 120T and FF 220T achieve an unusually deep bass response with our exclusive	Extron FF 220A	4
27	Beamforming Ceiling Array Microphone The microphone may be used singly or in multiples (for larger meeting spaces) to capture every person speaking in a room with clear, natural audio that reduces distracting environmental sounds. A state-of-the-art	Audio Technia ATND1061DAN	4
28	4-Port networked charging station charges handheld, bodypack, and boundary microphones. Features include charge status indicators, easy transmitter linking and overcharge protection for battery damage	Shure MXWNCS4 Charging Station	2
29	Audio network interface streamlines Microflex Wireless connectivity to	Shure MXWANI4 Audio Interface	1

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	conference room av systems over 4 channels to enable easy setup.		
30	The MXW Access Point (APT) mounts to a ceiling or wall for discreet communication between the wireless microphones and the digital audio network. Multiple access points can be used for installations that require simultaneous operation of up to 80 microphones in the same area, depending on the region. The MXW networked charging station charges and stores boundary and gooseneck microphones for tabletop applications, as well as handheld and bodypack solutions for corporate training and presentations. Control software is used for system setup and remote monitoring and control from any computer connected to the network.	Shure MXWPT4 Access Point Transceiver 4 channel	2
31	Wireless Microphone Kit, includes (1) Rack Mount Receiver, (1) Body-Worn Transmitter with Cardioid Lavalier (Clip-On) Microphone	Shure MXW1 Hybrid Body Pack	4
32	The handheld enables presenters to communicate using legendary Shure SM58, SM86, BETA58 and VP68 microphone cartridges.	Shure MXW2 Hand Held Receiver	4
33	Wireless Microphone Kit, includes (1) Rack Mount Receiver, (1) Body-Worn Transmitter with Cardioid Lavalier (Clip-On) Microphone	Shure BLX14R/W85-xx - includes the following: - (1) BLX4R Diversity Receiver - (1) BLX1 Bodypack Transmitter - (1) WL185 Cardioid Lavalier Mic - (1) Rack Mount Kit - (2) Antenna Extensions	2

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34	Wireless Microphone Kit, includes (1) Rack Mount Receiver, (1) Handheld SM 58 Transmitter	Shure BLX24B58-xx - includes the following: - (1) BLX4R Diversity Receiver - (1) BLX1 Bodypack Transmitter - (1) WL185 Cardioid Lavalier Mic - (1) Rack Mount Kit - (2) Antenna Extensions	2
	<i>RACKS</i>		
35	13 RU slide out and rotate rack 22X25-3/4 X 19 1/4"	Middle Atlantic SRSR-4-13	2
36	Rear Rack Rails, 24RU	Middle Atlantic DWR-RR24	2
37	Ultra Silent blower fans	Middle Atlantic UQFP-4	1
38	Security Rack Screws with Torx (Star) Security Bit, Provide Bit to Owner Upon Project Closeout	Middle Atlantic HTX (with TBIT)	3
39	Rack Mount Storage Drawer, 2 space, key-lockable	Middle Atlantic Products D2-LK	1
40	Controllable Rack Mount Power Distribution Unit, 6-Remotely Switchable Outlets, 1RU, Spike and Surge Protection, EMI Filter	SurgX SX-1115 RT	2
41	Blank Rack Panels - Solid	Middle Atlantic EBx	4
42	Brush Rack Panels	1RU BRUSH	4
	<i>Sound Masking</i>		
43	Sound Masking Processor/Speaker Controller	AtlasIED ASP-MG74	1
44	400W Networkable 4 Channel Power Amplifier with Dante	AtlasIED DPA-404	2
45	15LA Power Conditioner and Distribution	AtlasIED APS-15LA	1
46	8" Dual Cone Sound masking Speaker w- 4W 70V Trfmr	AtlasIED M1000	92
47	72" suspension chain for M1000 speakers	AtlasIED MCHAIN72	92
48	3" Full Range In-Ceiling speaker w- 16W-70V Transformer	AtlasIED FAP 33 T W	12
49	8" Dual Cone Sound masking Speaker w- 4W 70V Trfmr Round	AtlasIED M1000R	8
50	10 RU Wall Cabinet w- adjustable rails, 23" Deep	AtlasIED WMA10-23	1
51	1" Deep Micro-perf door for WMA 10 RU	AtlasIED MPFD10	1

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<i>Network</i>			
52	24 Port network switch w-POE & PoE+	OFCI	1
53	16 port network Switch w-PoE & PoE+	OFCI	1

SECTION 27 4224 - DIGITAL SIGNAGE VIDEO DISPLAYS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Related Sections: The following Sections contain requirements that relate to this Section.
 - 1. Division 09, Section related to structural backing in walls to receive mounts.
 - 2. Division 26, Section 26 0500, Common Work Results for Electrical Systems.
 - 3. Division 26, Section 26 0533, Raceways and Boxes for Electrical Systems.
 - 4. Division 26, Section 26 4313, Transient Voltage Surge Suppression for Low-Voltage Electrical Power Circuits.
 - 5. Division 27, Section 27 0500, Common Work Results for Communications.
 - 6. Division 27, Section 27 4100, Audio-Visual Systems.
 - 7. Division 27, Section 27 1622, Cabling for Audio-Visual Systems.

1.2 SYSTEM NARRATIVE

- A. Large-format flat panel LCD video/graphics monitors to function as public user interfaces and educational tools for the display of public announcements, way-finding information, mass notification messaging, and branding/advertising.

1.3 SUBMITTALS

- A. General: Submit each item in this Article according to the Conditions of the Contract and with Division 1 section requirements for Submittal Procedures.
- B. Product Data for each unique and/or typical component specified. Include the following:
 - 1. Manufacturer's technical product data sheet.
 - 2. Manufacturer's installation and maintenance instructions.
- C. Shop Drawings: Provide fabrication, rough-in, and installation details for mounting hardware and protective tamper-resistant shroud for flat panel video monitors. Include indications for dimensions, mounting methods, mounting heights and positions, structural attachment, accessories, and installation details. Include indications for wiring connections, use of raceways, and raceway concealment methods. Field-verify site conditions with dimensions shown on shop drawings.

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- D. Field inspection reports indicating any potential conflicts with nearby elements such as structural, architectural, casework or furnishings, mechanical, plumbing, lighting or electrical.

1.4 QUALITY ASSURANCE

- A. Source Limitations: Obtain common materials and equipment through one source from a single manufacturer as much as practical.
- B. Structural Support: Obtain bracing, support and structural anchorage design for all mounting solutions from a licensed structural engineer.
- C. Pre-installation meeting: Installing contractor shall organize and conduct pre-installation meetings with all other trades.
- D. All equipment for this installation will be new, less than one year from the date of manufacture, and without blemish or defect.
- E. All hardware shall be installed in a neat and workmanlike manner. All methods of construction that are not specifically described or indicated in the contract documents shall be subject to control and approval of the Architect and/or Owner's Representatives. The equipment specified herein represents the base standard of quality for acceptable manufacturers.
- F. The Contractor shall supply and install any incidental equipment needed in order to result in a complete and operable system without claim for additional payment, even if such equipment is not listed in this Specification.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Equipment, Cabling and Installation Materials:
 - 1. Costs of all shipping to the site, and of all unusual storage requirements, shall be borne by the Contractor. It shall be the responsibility of the Contractor to make appropriate arrangements, and to coordinate with the authorized personnel at the site, for the proper acceptance, handling, protections, and storage of equipment so delivered.
 - 2. Store in temperature- and humidity-controlled environment in original manufacturer's sealed containers. Maintain ambient temperature between 50 and 85 deg F (10 and 30 deg C), and not more than 80 percent relative humidity, non-condensing.
 - 3. Open each container; verify contents against packing list, and file copy of packing list, complete with container identification for inclusion in operation and maintenance data.
 - 4. Save original manufacturer's containers and packing materials and deliver as directed under provisions covering extra materials.

1.6 PROJECT CONDITIONS

- A. Environmental Conditions: System shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability.

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1. Interior, Controlled Environment: System components installed in temperature-controlled interior environments shall be rated for continuous operation in ambient conditions of 36 to 122 deg F (2 to 50 deg C) and 20 to 90 percent relative humidity.

1.7 WARRANTY

- A. Manufacturer Warranties: Submit to Owner or Owner's Representative all written and dated warranties, in addition to completed product support registration cards, as issued by product manufacturers warranting all individual components against defects in materials or manufacturing, for the periods established by said manufacturers. The start date of the warranties shall be the date of final system acceptance.

1.8 SERVICE CONTRACT

- A. As part of this Specification, the Contractor shall initiate a one-year service contract to commence on the date of final acceptance and continue to the first anniversary of the date of final acceptance as defined in 'System Acceptance'. The scope of the service contract would normally extend beyond warranty service calls, to include ongoing support of the video display systems such as maintenance, periodic replacement of consumables, Owner training or assistance, and/or additional design-build agreements.
- B. As part of the Bid Response, the Contractor shall provide the Owner with a proposal for continuation of the service contract to include Year Two, Year Three and Year Four of operation. All terms and conditions of the Year One Warranty shall apply.

1.9 PRIOR APPROVAL

- A. For substitutions of products specified herein, Contractor shall submit requests for prior approval at least seven (7) days prior to submitting bids, and in accordance with the provisions of Bidding Instructions and/or Division 1.

1.10 MAINTENANCE

- A. Extra Materials: If provided per the project requirements, extra materials shall be placed in suitable packaging or zip-locking bags, and shall be given to the building owner or owner's representative upon substantial completion of work.

PART 2 PRODUCTS

2.1 FLAT PANEL VIDEO MONITORS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide products by one of the following:
 1. LG Electronics – Commercial Display division
 2. Samsung Electronics – Professional Display division

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3. NEC Display Solutions – Business Displays
4. Sharp Electronics – Professional Display division
5. Panasonic Corporation – Professional Displays division

B. Minimum Product Performance Features:

1. Imager Technology: Back-lit LCD (TFT) panel
2. Image Sizes: As indicated in “Schedule of Digital Signage Displays” on Technology Drawings.
3. Native Resolution: 1920 by 1080 pixel matrix, conforming to 1080p/60 High Definition (HD) format as defined by Advanced Television Systems Committee (ATSC).
4. Brightness: 450 nits (cd/m²) minimum
5. Native Contrast Ratio: 3000:1 typical (minimum)
6. Response Time: 8 milliseconds (maximum)
7. Viewing Angle: 178 degrees horizontal / 178 degrees vertical (minimum)
8. VESA mounting interface
9. Inputs:
 - a. Qty. (2) HDMI, HDCP 1.4 compliant (minimum)
10. Control: RS-232

C. Hardware for Digital Signage:

1. Provide IP-addressable hardware network interface or “channel player” for each display. Hardware shall be the “Hyper Media Player” model # HMP300 as manufactured by SpinetiX.
2. Hardware shall be capable of providing high-definition (HD) video as well as high-resolution computer graphics media to the video monitors at the native resolution of the monitors.
3. Hardware shall be capable of automated control of the following video monitor functions (minimum):
 - a. Power On and Power Off (using discrete power commands)
 - b. Input selection
 - c. Volume Up / Down
 - d. Audio Mute

D. Software Suite for Digital Signage / Content Playback:

1. Provide Qty. (2) License Keys for the “Elementi X” software application by SpinetiX.
2. Remote management and control of all video displays connected to the building IP LAN infrastructure.
3. Content development, authoring, scheduling and payout to all video displays connected to network.

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4. RSS feed capability providing optional graphical updates on all video displays, including but not limited to weather forecasts and current conditions; stock market quotes; time of day; game scores.
5. Web-based server providing administrative access and control via remote location that is connected to the Internet

2.2 TILTING WALL MOUNT

- A. Where indicated in “Schedule of Digital Signage Displays” on Technology Drawings: provide tilting wall mount for flat panel video display.
- B. Basis-of-Design Product: Model LTA1U as manufactured by the following: Chief Manufacturing Inc.
 1. Chief Manufacturing Inc, 8401 Eagle Creek Parkway, Savage, Minnesota, 55378, phone (800) 582-6480, website www.chiefmfg.com
- C. Product Features:
 1. Low-profile tilt uses the center of gravity to balance the screen while maintaining a low profile.
 2. Provides up to 17.5" of post-installation lateral shift – 8.75" left/right of uprights - for limitless centering.
 3. Offers an audible click when the screen safely engages with the mount.
 4. Built-in cable stand provides easy access under the screen.
 5. A full line of accessories can be installed with the mount and the entire unit can be adjusted together.
 6. Provides integrated security, just add a padlock.
 7. Ships with a custom hardware kit.
- D. Technical Specifications:
 1. Minimum Depth from Wall: 2"
 2. Tilt: +0°, -12°
 3. Max Lateral Shift: 17.4"
 4. Mounts on Studs: 16", 20", 24", 32"
 5. Dimensions (HxWxD): 16.5" x 34.75" x 2"
 6. Max Mounting Pattern: height - 19.7", width - 34.25"
 7. Weight Capacity: 200 lbs
 8. Color: Black
- E. Method of Installation:
 1. Determine location for mount keeping in mind display size, extension, height adjustment (if applicable), and pitch/roll requirements.

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2. Wall mounting plate shall be installed over structurally reinforced wall using backing material behind finishing wallboard. Refer to Drawings for details.

F. Mounting Accessories:

1. Installation hardware: Provide additional mounting hardware, fasteners, and other components of type, size, and spacing recommended by manufacturer for complete, functional, secure installation.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify final locations of conduit and back box rough-in's prior to commencing any work.
- B. Examine pathway elements intended for cables. Check raceways, cable trays, and other elements for compliance with space allocations, installation tolerances, hazards to cable installation, and other conditions affecting installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Prior to commencing any work, coordinate requirements for enclosure mounting location, rough opening in wall, power and communications pathways and wiring, and structural with architect.
- B. In meetings with Architect and Owner, present Project planning documents and review, adjust, and prepare final setup documents. Use final documents to set up system software.

3.3 GENERAL INSTALLATION PRACTICES

- A. Install displays and associated hardware/equipment at locations and heights indicated on Drawings. Verify locations in field with Architect prior to commencing any work.
- B. Install displays and associated hardware/equipment in accordance with approved shop drawings and manufacturer's installation instructions.
- C. All equipment with the exception of portable equipment shall be firmly fastened or attached in place. A safety factor of at least four shall be utilized for all brackets, fasteners and attachments.
- D. In the installation of equipment and cable, consideration shall be given not only to operational efficiency, but also to overall aesthetic factors.
- E. The Contractor shall ensure that all equipment is installed such that proper cooling and ventilation is provided for electronics.

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- F. All equipment shall be installed in a manner, which prevents hum, RF/EMI/EMF interference, and mechanical vibration based noises (e.g. fan mounts, etc.)
- G. All equipment shall be protected from construction dust and debris until final acceptance of the system.
- H. All equipment shall be protected from theft until final acceptance of the system.
- I. The Contractor shall be under obligation to protect completed work and uncompleted work against damage or loss until the Owner has given final acceptance. Should the need arise to repair work or replace items. The Contractor shall do so at no cost to the Owner.

3.4 GROUNDING

- A. Comply with Division 26 Section "Grounding and Bonding for Electrical Systems."
- B. Comply with IEEE 1100, "Power and Grounding Sensitive Electronic Equipment."
- C. Ground cable shields, drain conductors, and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
- D. Bond shields and drain conductors to ground at only one point in each circuit.
- E. Bond all metal housings, mounting hardware, etc.

3.5 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain AV system. Refer to Division 01 Section "Demonstration and Training."

3.6 TRAINING

- A. The Contractor shall provide a total of two (2) hours of on-site training for the Owner's staff separated into two (2) sessions each of one (1) hour at a minimum 1-week interval, at a time that is mutually agreeable for the Owner and Contractor. Additionally, the Contractor shall be responsible for facilitating a minimum of two (2) hours of online/web-based training from the manufacturer for the Owner's staff. Final acceptance and/or final payment for the system shall not be delayed due to scheduling delays beyond the control of the Contractor.

3.7 SYSTEM ACCEPTANCE

- A. Upon successful completion of Final Tests, Documentation and Training, the Contractor shall notify the Owner, in writing, that the system is complete. The Owner shall have twenty (20) days to generate a "punch list" of omissions, adjustments, corrections and the like and respond in writing to the Contractor. In the absence of such a "Punch List," the system shall be considered to be complete. The warranty shall commence on the twentieth day after the Contractor's notification of completion of work, and the Owner shall process final payment. In

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the event that further work is required to complete this project, the Contractor shall be prepared to continue work, without additional compensation, until the system is accepted.

END OF SECTION

SECTION 27 5119 - SOUND-MASKING SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Networked sound masking systems.
 - 2. Standalone sound masking systems.
- B. Products Installed, but Not Furnished, under This Section:
 - 1. See Section 260553 "Identification for Electrical Systems" for electrical equipment.
- C. Related Requirements:
 - 1. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.
 - 2. Section 270010 "Supplemental Requirements for Communications" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.

1.2 DEFINITIONS

- A. FACU: Fire-alarm control unit.
- B. N.O.: Normally open.
- C. N.C. Normally Close
- D. GAIN: Adjustment of input and output gains to reach 47db.
- E. ASP-MG24 Sound Masking Processor-Speaker Control
- F. M 1000 8" Dual Cone 4W 70V Speaker
- G. DPA404 400 Watt 4 channel power amplifiers
- H. MCHAIN72 72" Suspension Chain for M000 Speakers
- I. FAP33T-W 3" Full Range in-ceiling speaker 16Watt 70V Transformer
- J. M1000R Dual Cone 4W 70V Speaker
- K. WMA10-23 10RU-23" deep wall mount rack

- L. MDFD10 1” Deep Micro-perf Door for WMA 10 RU

1.3 ACTION SUBMITTALS

Action submittals are submittals requiring responsive action and the return of reviewed documents to Contractor.

- A. Product Data:
 - 1. Standalone sound masking systems.
 - a. ASP-MG24 Sound Masking Processor-Speaker Control
- B. Shop Drawings:
 - 1. Shop drawings for sound masking systems.
- C. Field quality-control reports.
- D. Sustainable design submittals.

1.4 INFORMATIONAL SUBMITTALS

- A. Manufacturers' Published Instructions:
 - 1. Standalone sound masking systems.
- B. Field Reports:
 - 1. Manufacturer's field reports for field quality-control support.
 - 2. Manufacturer's field reports for system startup support.
 - 3. Field reports for software and firmware upgrades.

1.5 CLOSEOUT SUBMITTALS

- A. Submittals for record documents, operation and maintenance data, software, and software documentation are specified in Section 270010 "Supplemental Requirements for Communications."
- B. Warranty documentation.
- C. Sustainable design closeout documentation.

1.6 WARRANTY FOR SOUND MASKING SYSTEMS

- A. When warranties are required and available, verify with Owner's counsel that special warranties stated in this article are not less than remedies available to Owner, after one-year correction period specified in the Contract, under Contractor's general warranty and prevailing local laws.

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- B. Verify durations of extended-warranty periods needed.
- C. Special Installer Extended Warranty: Installer warrants that fabricated and installed sound masking systems perform in accordance with specified requirements and agrees to repair or replace components or products that fail to perform as specified within extended-warranty period.
 - 1. Extended-Warranty Period: 1 year from date of Substantial Completion; full coverage for labor, materials, and equipment.
- D. Special Manufacturer Extended Warranty: Manufacturer warrants that sound masking systems perform in accordance with specified requirements and agrees to provide repair or replacement of components or products that fail to perform as specified within extended-warranty period.
 - 1. Extended-Warranty Period: 2 years from date of Substantial Completion; coverage for materials only, free on board, freight prepaid.
 - 2. Follow-On Extended-Warranty Period for Li-ion Batteries: [**1**] years from date of Substantial Completion; prorated coverage for materials only, free on board, freight prepaid.

PART 2 - PRODUCTS

- A. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
 - 1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
 - 2. Audio Equipment: Comply with one of the following:
 - a. UL CCN AZOT; including UL 62368-1.
 - b. UL CCN AZSQ; including UL 60065 or UL 6500.
 - c. UL CCN AZJX; including UL 813.
 - d. Suitable for Installation in Air-Handling Spaces: UL CCN BHZF; including UL 2043.
 - 3. Options:
 - a. Loudspeaker Mounting: In ceiling, above ceiling.
 - b. Loudspeaker Controller Mounting: Network Closet
 - c. k controller to mute paging, background music, and other audio programming.
 - d. Masking Sound Frequency Range: 20hz-20Kh, with equalizers for adjusting the masking sound spectrum at third-octave resolution.
 - e. Masking Sound Volume Adjustment: Digital control, adjustable in 0.5 dB 1.5 dB 5 dB 2 db increments over the range of 34 to 82 or a continuous adjustment within that range.
 - f. Masking Preset Contour Options:

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- g. Spare Parts: Furnish to Owner spare parts, for repairing sound masking equipment, that are packaged with protective covering for storage on-site and identified with labels describing contents.
 - 1) AtlasIED M1000 Speaker Quantity 2
 - 2) AtlasIED M1000R Speaker Quantity 2
- h. Special Tools: Furnish to Owner proprietary equipment, keys, and software required to operate, maintain, repair, adjust, or implement future changes to sound masking equipment, that are packaged with protective covering for storage on-site and identified with labels describing contents
 - 1) Keys for rack, passwords for controller, program non-compiled and compiled.

2.2 STANDALONE SOUND MASKING SYSTEMS

- A. Description: Self-contained loudspeaker with electronic noise generator and associated controls.
- B. Performance Criteria:
 - 1. 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.
 - 2. General Characteristics:
 - a. Reference Standards: Complies with principles and recommended test methods described in ASTM E1374.
- C. Source Quality Control
- D. UL UEAY - Standalone Sound Masking Loudspeakers
 - a. Sound Masking Loudspeakers: UL CCN UEAY; including UL 1480A.
 - b. Suitable for Installation in Air-Handling Spaces: UL CCN BHZF; including UL 2043.
 - c. Loudspeaker Mounting: Ceiling and above ceiling
 - d. Loudspeaker Controller Mounting: Wall
 - e. Special Tools: Furnish to Owner proprietary equipment, keys, and software required to operate, maintain, repair, adjust, or implement future changes to sound masking equipment, that are packaged with protective covering for storage on-site and identified with labels describing contents.
- E. UL AZOT - Single-Room Sound Masking System
 - 1. Source Limitations: Obtain products from single manufacturer.
 - 2. Listing Criteria:
 - a. Audio Equipment: Comply with one of the following:
 - 1) UL CCN AZOT; including UL 62368-1.

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- 2) UL CCN AZSQ; including UL 60065 or UL 6500.
- 3) UL CCN AZJX; including UL 813.
- b. Suitable for Installation in Air-Handling Spaces: UL CCN BHZF; including UL 2043.
- 3. Options:
 - a. Loudspeaker Mounting: In plenum area and on ceiling.
 - b. Loudspeaker Controller Mounting: Wall

2.3 PREPARATION

- A. Shop Drawings: Prepare and submit the following:
 - 1. Shop Drawings for Sound Masking Systems:
 - a. Include plans, elevations, sections, details, and attachments to other work.
 - b. Include schematic of system and floor plan indicating quantity, type, and location of components.
 - c. Include diagrams for power, signal, and control wiring.
 - d. Include details supplementing assembly and installation instructions with dimensions, weights, loads, required clearances, methods of field assembly, components, and location and rating of each field connection.

2.4 INSTALLATION OF SOUND MASKING SYSTEMS

- A. Comply with manufacturer's published instructions.
- B. Reference Standards for Installation:
 - 1. Audio Equipment and Wiring Methods: Unless requirements that are more stringent are specified in Contract Documents or manufacturers' published instructions, comply with Article 640 of NFPA 70.
 - 2. Consult Architect for resolution of conflicting requirements.
- C. Special Installation Techniques:
 - 1. Loudspeaker Installation above Ceiling: Suspend with chains from building structure above ceilings, so bottom of assembly is 6 to 8 inch above upper plane of finished ceiling material. Use eyebolts on speaker assemblies for attachment. Suspend independently from structure, not to supports for components of other building systems.
 - 2. Zoned Loudspeaker Connections: For 4-channel systems, connect loudspeaker assemblies alternatively, so masking sound is redundant throughout coverage zones.
 - 3. Wiring Methods:
 - a. Cable in Raceway: Install cables in raceways and cable trays, except within consoles, cabinets, desks, and counters and unless otherwise indicated.

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- 1) Except raceways are not required in accessible indoor ceiling spaces and attics.
 - 2) Except raceways are not required in hollow gypsum board partitions.
 - 3) Conceal raceways and wiring, except in unfinished spaces.
 - b. Concealed Cable: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
 - c. Exposed Cable: Install parallel to building lines, follow surface contours, and support as recommended by manufacturer.
 - 1) Install plenum cable in environmental air-handling spaces, including plenum ceilings.
 - d. Within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.
 4. Grounding: As recommended by manufacturers unless more stringent requirements are indicated. Ground equipment and conductors to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments with a maximum of 5 Ω to ground at main equipment location. (MEASURE)
 5. Impedance Matching: For system components, including connecting cable, provide end-to-end level and impedance-matched signal paths. Use matching networks and balancing devices at connections where necessary to avoid mismatches.
 6. Splices, Taps, and Terminations: Make splices, taps, and terminations in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.
 7. Use color-coded conductors, and apply wire- and cable-marking tape to designate wires and cables, so media are identified in coordination with system wiring diagrams.
 - a. Label loudspeakers as to channel, zone, and address.
 - b. Identify field-installed conductors, interconnecting wiring, and components.
 - c. Provide warning signs.
 - d. Label each enclosure with engraved metal or laminated-plastic nameplate.
- D. Interfaces with Other Work:
1. Coordinate quantity and arrangement of sound masking system components with ceiling space configuration and with components occupying ceiling space, including structural members, pipes, air-distribution components, raceways, cable trays, luminaires, and other items.
 2. Coordinate with Section 270528 "Pathways for Communications Systems" for raceway system material, routing, and locations.
 3. Coordinate with Section 260533.13 "Conduit for Electrical Systems" for installation of raceways.
 4. Coordinate with Section 260533.16 "Boxes and Covers for Electrical Systems" for installation of boxes.
 5. Coordinate with Section 271513 "Communications Copper Horizontal Cabling" for installation of network cabling, loudspeaker cabling, and Class 2 control cabling.

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- E. Systems integration.
1. Pre -installation coordination meetings may be required for offices occupied by government or offices occupied by government contractors that require certification of spaces after construction.
 2. Pre- installation Coordination Meeting(s): For sound masking systems. Conduct meeting(s) at Project site
 3. Attendees: Installers, fabricators, representatives of manufacturers, and administer for field tests and inspections. Notify Architect, Construction Manager , and Owner's Commissioning Authority of scheduled meeting dates.

2.5 FIELD QUALITY CONTROL OF SOUND MASKING SYSTEMS

- A. Acceptance Testing Preparation:
1. Pretesting: Tune, align, and adjust system, and pretest components, wiring, and functions to verify compliance with specified material, installation, and performance requirements. Correct deficiencies and retest until satisfactory performance and conditions are achieved.
- B. The consultant must witness Field tests and inspections. Bridgers and Paxton
- C. Tests and Inspections:
1. Perform manufacturer's recommended tests and inspections.
 2. Operational Test: Start system to confirm proper operation. Remove malfunctioning units, replace with new units, and retest. Make initial sound-spectrum and -level adjustments for each zone.
 3. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.
 4. Masking Sound Power Level Adjustments: Adjust independently for each space to minimum level between 47 and 50 dB(A-weighted) that will provide speech privacy between adjacent workstations while complying with other system requirements.
- D. Final Acceptance Testing: Provide a minimum of 10 days' notice of acceptance test performance schedule. Schedule tests after pretesting has been successfully completed.
1. Perform sound masking evaluation tests in accordance with ASTM E1130 ASTM E1573, with measurements and calculations in accordance with ASA S3.5.
 2. Tests and Calibration Conditions: Spaces are to be completely furnished, but unoccupied; lights and HVAC systems must be on; HVAC system testing and balancing are to be completed; and electronic ballasts, lighting relay panels, and low-voltage transformers must be in place.
 3. Test Conditions: Complying with ASTM E1130 and calculated in accordance with ASA S3.5.
 4. Instrumentation: Use a professional-quality, sound-level meter with octave-band filters and documentation of recent calibration against recognized standards. Comply with ASA S1.4 Part 1.

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5. System Tests: Include the following for each system zone:
 - a. Loudspeaker Circuit Impedance Test: Measure impedance at 1000 Hz with amplifier disconnected, using a professional impedance meter or bridge. Locate and correct faults denoted by abnormal readings.
 - b. Ambient Sound-Level Tests: With system off, measure ambient sound level in one-third octave bands. Also measure ambient sound level as a single, wide-band, A-weighted reading.
 - c. System Noise Test: With masking-noise signal on and amplifiers adjusted at a working level 10 dB above ambient sound level, check for hum, buzz, rattle, or other operating deficiencies.
 - d. Spatial Uniformity Test: Measure sound level at locations no greater than 15 ft on center throughout covered spaces to determine compliance with specified performance level.
 - e. Frequency Response Adjustment and Test: Adjust one-third octave frequency bands and other unit filters to provide response. Adjust to meet requirement of space speech intelligibility and quality of background sound. Comply with ASA S3.2, CTA-426, and ASTM E1110.
- 5- Adjust level of masking sound that is appropriate for area and overall volume.
6. Adjust level of masking sound for each space, so one-third octave band centered at 500 Hz has final selected sound-power level for that space. Measure deviation from listed values in one-third octave bands from 100 to 1000 Hz. Measured values must not deviate from those listed by more than 4 dB for open-plan areas and 8 dB for enclosed offices. The total of individual band deviations in eight bands must not exceed 16 dB for open-plan areas and 30 dB for enclosed offices.
7. Walk-Through Test: People in covered spaces cannot discern loudspeaker locations.
- E. Record test observations, readings, and corrective actions. Report test results in accordance with ASTM E1130 ASTM E1573
- F. Record final control settings and programming, and final tap setting of loudspeaker-matching transformers. Record final sound-level measurements and observations.
- G. Nonconforming Work:
 1. Units will be considered defective if they do not pass tests and inspections.
 2. Remove and replace defective units and retest.
- H. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.
- I. Manufacturer Services: Engage factory-authorized service representative to support field tests and inspections.
 1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at Project site.

2.6 SYSTEM STARTUP

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- A. Perform startup service.
 - 1. Complete installation and startup checks in accordance with manufacturer's published instructions.
- B. Manufacturer Services: Engage factory-authorized service representative to support system startup.
 - 1. Manufacturer's Field Reports for System Startup Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at Project site.

2.7 ADJUSTING

- A. Sound Masking Adjustments: Adjust sound masking devices to suit actual occupied conditions.

2.8 PROTECTION

- A. After installation, protect sound masking equipment 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.

2.9 MAINTENANCE

- A. Sound Masking Readjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in readjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.
- B. Software and Firmware Service Agreement:
 - 1. Technical Support: Beginning at Substantial Completion, verify that software and firmware service agreement includes software and firmware support for one years.
 - 2. Upgrade Service: At Substantial Completion, update software and firmware to latest version. Install and program software and firmware upgrades that become available within one years from date of Substantial Completion.
 - a. Upgrade Notice: No fewer than 30 days to allow Owner to schedule and access the system.
 - 3. Field Reports for Software and Firmware Upgrades: Prepare and submit report after each update, documenting upgrades installed.

END OF SECTION

SECTION 28 0526 - GROUNDING AND BONDING FOR ELECTRONIC SAFETY AND SECURITY

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Refer to Technology responsibility matrix, located on plan set for further information.
- B. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- C. State of NM DoIT – Standard for Building and Campus Distribution Systems

1.2 SUMMARY

- A. Section Includes:
 - 1. Grounding conductors.
 - 2. Grounding connectors.
 - 3. Grounding busbars.

1.3 DEFINITIONS

- A. Signal Ground: The ground reference point designated by manufacturer of the system that is considered to have zero voltage.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: **Cabling Installer must have personnel certified by BICSI on staff.**
 - 1. Layout Responsibility: Preparation of Shop Drawings and Cabling Administration Drawings, Cabling Administration Drawings, and field testing program development by an RCDD.
 - 2. Installation Supervision: Installation shall be under the direct supervision of Registered Technician, or Level 2 Installer, who shall be present at all times when Work of this Section is performed at Project site.
 - 3. Testing Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

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- B. Testing Agency Qualifications: An NRTL.
 - 1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

1.6 QUALIFICATIONS

- A. Communications Cabling: The Contractor shall have (5) five years of documented experience performing cable placement, splicing, termination, connecting, and testing for each of the media types and (3) three years of applicable experience with the proposed system manufacturer. In the case of newer technologies that do not have a (3) three year history, the Contractor shall have documented experience for at least half of the lifetime of the new technology. The approved contractor shall, at a minimum, maintain a ratio of one manufacturer or BICSI certified installer for every two non-certified installers assigned to the project.
- B. The contractor shall have on staff a BICSI Certified RCDD as a permanent employee. This staff member shall have been on staff for a minimum of (1) one year prior to the date of this projects release for bid.
- C. The contractor shall have on staff at least (1) one BICSI Certified Technician and this staff member shall have been a full time employee for no less than (1) one year prior to the date of this projects release for bid. A BICSI Certified Technician shall be employed as the on-site Field Supervisor for this project.
- D. The contractor shall provide resumes for the Project Manager, Supervisors and any skilled technicians or installers. Each resume shall include applicable certification documents provided by the manufacturer or BICSI.
 - 1. Project Manager, Supervisors, and Principal Skilled Technicians: minimum of (5) five years' experience in like work.
 - 2. Category 6 Unshielded Twisted Pair and Fiber Optic Cable Technicians: documented training, licensing, and/or certification for the types of media specified, as applicable as well as certification from the manufacturer of the solution chosen by the owner.

1.7 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer, qualified layout technician, installation supervisor, field inspector and company. The contractor shall provide resumes for the Project Manager, Supervisors and any skilled technicians or installers. Each resume shall include applicable certification documents provided by the manufacturer or BICSI.
 - 1. Project Manager, installation supervisor, and Principal Skilled Technicians: As a minimum be required to have no less than (5) five years' experience in like work.
 - 2. The Company/Contractor proposing shall provide historical data confirming the company has a minimum of (5) five years applicable experience.
 - 3. The Company/Contractor shall have a minimum of (3) three projects of similar size and type within the last (2) years. References for all submitted projects are required to assist with the evaluation.

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- B. Category 6 Unshielded Twisted Pair and Fiber Optic Cable Technicians: Documented training, licensing, and/or certification for the types of media specified, as applicable as well as certification from the manufacturer of the solution chosen by the owner.
- C. Source quality-control reports.
- D. Field quality-control reports.

PART 2 PRODUCTS

2.1 CONDUCTORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work include the following:
 - 1. Harger Lightning and Grounding.
 - 2. Panduit Corp.
 - 3. Tyco Electronics Corp.
- B. Comply with UL 486A-486B.
- C. 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.
- 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 (14.2 sq. mm), 14 strands of No. 17 AWG conductor, and 1/4 inch (6.3 mm) in diameter.
 - 5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
 - 6. Bonding Jumper: Tinned-copper tape, braided conductors terminated with two-hole copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.

2.2 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.

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- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work include the following:
 - 1. Burndy; Part of Hubbell Electrical Systems.
 - 2. Chatsworth Products, Inc.
 - 3. Harger Lightning and Grounding.
 - 4. Panduit Corp.
 - 5. Tyco Electronics Corp.
- C. 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.
- D. Busbar Connectors: Cast silicon bronze, solderless compression or exothermic-type mechanical connector; with a long barrel and two holes spaced on 5/8- or 1-inch (15.8- or 25.4-mm) centers for a two-bolt connection to the busbar.
- E. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

2.3 GROUNDING BUSBARS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work include the following:
 - 1. Chatsworth Products, Inc.
 - 2. Harger Lightning and Grounding.
 - 3. Panduit Corp.
- B. Grounding Busbars: Predrilled rectangular bars of hard-drawn solid copper, 1/4 by 2 inches (6.3 by 50 mm) in cross section, length as indicated on Drawings. The busbar shall be for wall mounting, shall be NRTL listed as complying with UL 467, and shall comply with J-STD-607-A.
 - 1. Predrilling shall be with holes for use with lugs specified in this Section.
 - 2. Mounting Hardware: Stand-off brackets that provide at least a 2-inch (50-mm clearance to access the rear of the busbar. Brackets and bolts shall be stainless steel.)
 - 3. Stand-off insulators for mounting shall be Lexan or PVC. Comply with UL 891 for use in 600 V switchboards, impulse tested at 5000 V.
- C. Rack and Cabinet Grounding Busbars: Rectangular bars of hard-drawn solid copper, accepting conductors ranging from No. 14 to No. 2/0 AWG, NRTL listed as complying with UL 467, and complying with J-STD-607-A. Predrilling shall be with holes for use with lugs specified in this Section.

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1. Cabinet-Mounted Busbar: Terminal block, with stainless-steel or copper-plated hardware for attachment to the cabinet.
2. Rack-Mounted Horizontal Busbar: Designed for mounting in 19- or 23-inch (483- or 584-mm) equipment racks. Include a copper splice bar for transitioning to an adjoining rack, and stainless-steel or copper-plated hardware for attachment to the rack.
3. Rack-Mounted Vertical Busbar: 72 or 36 inches (1827 or 914 mm long), with stainless-steel or copper-plated hardware for attachment to the rack.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Comply with IEEE 1100, "Recommended Practice for Power and Grounding Electronic Equipment."
 1. Ground cable shields, drain conductors, and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
 2. Bond shields and drain conductors to ground at only one point in each circuit.
- B. Signal Ground:
 1. For each system, establish the signal ground and label that location as such.
 2. Bond the signal ground to the alternating-current (ac) power system service by connecting to one of the following listed locations, using insulated No. 6 AWG, stranded, Type THHN wire:
 - a. Grounding bar in an electrical power panelboard if located in the same room or space as the signal ground.
 - b. Telecommunications grounding busbar.
- C. Comply with NECA 1.

3.2 APPLICATION

- A. Conductors: Install solid conductor for No. 8 AWG and smaller and stranded conductors for No. 6 AWG and larger unless otherwise indicated.
- B. Grounding and Bonding Conductors:
 1. Install in the straightest and shortest route between the origination and termination point, and no longer than required. The bend radius shall not be smaller than eight times the diameter of the conductor. No one bend may exceed 90 degrees.
 2. Install without splices.
 3. Support at not more than 36-inch (900-mm) intervals.

3.3 CONNECTIONS

- A. Stacking of conductors under a single bolt is not permitted when connecting to busbars.
- B. 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.
- C. Shielded Cable: Bond the shield of shielded cable to the signal ground. Comply with TIA/EIA-568-B.1 and TIA/EIA-568-B.2 when grounding screened, balanced, twisted-pair cables.
- D. Rack- and Cabinet-Mounted Equipment: Bond powered equipment chassis to the cabinet or rack grounding bar. Power connection shall comply with NFPA 70; the equipment grounding conductor in the power cord of cord- and plug-connected equipment shall be considered as a supplement to bonding requirements in this Section.

3.4 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.
- C. Grounding system will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

END OF SECTION

SECTION 28 0528 - PATHWAYS FOR ELECTRONIC SAFETY AND SECURITY

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. State of NM DoIT – Standard for Building and Campus Distribution Systems

1.2 SUMMARY

- A. Section Includes:
 - 1. Metal conduits, tubing, and fittings.
 - 2. Nonmetallic conduits, tubing, and fittings.
 - 3. Optical-fiber-cable pathways and fittings.
 - 4. Metal wireways and auxiliary gutters.
 - 5. Nonmetallic wireways and auxiliary gutters.
 - 6. Boxes, enclosures, and cabinets.
 - 7. Handholes and boxes for exterior underground cabling.
- B. Related Requirements:
 - 1. Section 26 0533 "Raceways and Boxes for Electrical Systems" for conduits, wireways, surface raceways, boxes, enclosures, cabinets, handholes, and faceplate adapters serving electrical systems.
 - 2. Section 27 0528 "Pathways for Communications Systems" for conduits, surface pathways, innerduct, boxes, and faceplate adapters serving communications systems.

1.3 DEFINITIONS

- 1. ARC: Aluminum rigid conduit.
- 2. GRC: Galvanized rigid steel conduit.
- 3. IMC: Intermediate metal conduit.

1.4 ACTION SUBMITTALS

- A. Product Data: For wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.
- B. Shop Drawings: For entire system. Include plans, elevations, sections, and attachment details.

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- C. Samples: For wireways, nonmetallic wireways and surface pathways and for each color and texture specified, 12 inches (300 mm) long.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.
 - 1. Layout Responsibility: Preparation of Shop Drawings and Cabling Administration Drawings, Cabling Administration Drawings, and field testing program development by an RCDD.
 - 2. Installation Supervision: Installation shall be under the direct supervision of Registered Technician, or Level 2 Installer, who shall be present at all times when Work of this Section is performed at Project site.
 - 3. Testing Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.
- B. Testing Agency Qualifications: An NRTL.
 - 1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

1.6 QUALIFICATIONS

- A. Communications Cabling: The Contractor shall have (5) five years of documented experience performing cable placement, splicing, termination, connecting, and testing for each of the media types and (3) three years of applicable experience with the proposed system manufacturer. In the case of newer technologies that do not have a (3) three year history, the Contractor shall have documented experience for at least half of the lifetime of the new technology. The approved contractor shall, at a minimum, maintain a ratio of one manufacturer or BICSI certified installer for every two non-certified installers assigned to the project.
- B. The contractor shall have on staff a BICSI Certified RCDD as a permanent employee. This staff member shall have been on staff for a minimum of (1) one year prior to the date of this projects release for bid.
- C. The contractor shall have on staff at least (1) one BICSI Certified Technician and this staff member shall have been a full time employee for no less than (1) one year prior to the date of this projects release for bid. A BICSI Certified Technician shall be employed as the on-site Field Supervisor for this project.
- D. The contractor shall provide resumes for the Project Manager, Supervisors and any skilled technicians or installers. Each resume shall include applicable certification documents provided by the manufacturer or BICSI.
 - 1. Project Manager, Supervisors, and Principal Skilled Technicians: minimum of (5) five years' experience in like work.
 - 2. Category 6 Unshielded Twisted Pair and Fiber Optic Cable Technicians: documented training, licensing, and/or certification for the types of media specified, as applicable as well as certification from the manufacturer of the solution chosen by the owner.

1.7 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer, qualified layout technician, installation supervisor, field inspector and company. The contractor shall provide resumes for the Project Manager, Supervisors and any skilled technicians or installers. Each resume shall include applicable certification documents provided by the manufacturer or BICSI.
 - 1. Project Manager, installation supervisor, and Principal Skilled Technicians: As a minimum be required to have no less than (5) five years' experience in like work.
 - 2. The Company/Contractor proposing shall provide historical data confirming the company has a minimum of (5) five years applicable experience.
 - 3. The Company/Contractor shall have a minimum of (3) three projects of similar size and type within the last (2) years. References for all submitted projects are required to assist with the evaluation.
- B. Category 6 Unshielded Twisted Pair and Fiber Optic Cable Technicians: Documented training, licensing, and/or certification for the types of media specified, as applicable as well as certification from the manufacturer of the solution chosen by the owner.
- C. Source quality-control reports.
- D. Field quality-control reports.
- E. 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.
- F. Qualification Data: For professional engineer.
- G. Seismic Qualification Certificates: For pathway racks, enclosures, cabinets, and equipment racks and their mounting provisions, include 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.

PART 2 PRODUCTS

2.1 METAL CONDUITS, TUBING, AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, 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. AFC Cable Systems, Inc.
 2. Allied Tube & Conduit.
 3. Alpha Wire Company.
 4. Anamet Electrical, Inc.
 5. Electri-Flex Company.
 6. O-Z/Gedney.
 7. Picoma Industries.
 8. Republic Conduit.
 9. Robroy Industries.
 10. Southwire Company.
 11. Thomas & Betts Corporation.
 12. Western Tube and Conduit Corporation.
 13. Wheatland Tube Company.
- B. General Requirements for Metal Conduits and Fittings:
1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 2. Comply with TIA-569-B.
- C. GRC: Comply with ANSI C80.1 and UL 6.
- D. ARC: Comply with ANSI C80.5 and UL 6A.
- E. IMC: Comply with ANSI C80.6 and UL 1242.
- F. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit, IMC.
1. Comply with NEMA RN 1.
 2. Coating Thickness: 0.040 inch (1 mm), minimum.
- G. EMT: Comply with ANSI C80.3 and UL 797.
- H. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.
1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886 and NFPA 70.

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2. Fittings for EMT:
 - a. Material: Steel or die cast.
 - b. Type: Setscrew or 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 (1 mm), with overlapping sleeves protecting threaded joints.
- I. Joint Compound for IMC, GRC, or ARC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 NONMETALLIC CONDUITS, TUBING, AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, 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. AFC Cable Systems, Inc.
 2. Allied Tube & Conduit.
 3. Anamet Electrical, Inc.
 4. Arnco Corporation.
 5. CANTEX Inc.
 6. CertainTeed Corporation.
 7. Condux International, Inc.
 8. Electri-Flex Company.
 9. Kraloy.
 10. Lamson & Sessions; Carlon Electrical Products.
 11. Niedax-Kleinhuis USA, Inc.
 12. RACO; Hubbell.
 13. Thomas & Betts Corporation.
- B. General Requirements for Nonmetallic Conduits and Fittings:
1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 2. Comply with TIA-569-B.
- C. ENT: Comply with NEMA TC 13 and UL 1653.
- D. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.
- E. LFNC: Comply with UL 1660.

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- F. Rigid HDPE: Comply with UL 651A.
- G. Continuous HDPE: Comply with UL 651B.
- H. RTRC: Comply with UL 1684A and NEMA TC 14.
- I. Fittings for ENT and RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.
- J. Fittings for LFNC: Comply with UL 514B.
- K. Solvent cements and adhesive primers shall have a VOC content of 510 and 550 g/L or less, respectively, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- L. Solvent cements and adhesive primers shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.3 OPTICAL-FIBER-CABLE PATHWAYS AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, 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. Alpha Wire Company.
 - 2. Arcco Corporation.
 - 3. Endot Industries Inc.
 - 4. IPEX.
 - 5. Lamson & Sessions; Carlon Electrical Products.
- B. Description: Comply with UL 2024; flexible-type pathway, approved for plenum riser or general-use installation unless otherwise indicated.
 - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 2. Comply with TIA-569-B.

2.4 METAL WIREWAYS AND AUXILIARY GUTTERS

- A. Manufacturers: Subject to compliance with requirements, 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. Cooper B-Line, Inc.
 - 2. Hoffman.
 - 3. Mono-Systems, Inc.
 - 4. Square D.

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- B. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 1 Type 3R Type 4 Type 12, dependent on environmental conditions, unless otherwise indicated, and sized according to NFPA 70.
 - 1. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 2. Comply with TIA-569-B.
- C. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
- D. Wireway Covers: Hinged type, Screw-cover type or Flanged-and-gasketed type unless otherwise indicated.
- E. Finish: Manufacturer's standard enamel finish.

2.5 NONMETALLIC WIREWAYS AND AUXILIARY GUTTERS

- A. Manufacturers: Subject to compliance with requirements, 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. Allied Moulded Products, Inc.
 - 2. Hoffman.
 - 3. Lamson & Sessions; Carlon Electrical Products.
 - 4. Niedax-Kleinhuis USA, Inc.
- B. General Requirements for Nonmetallic Wireways and Auxiliary Gutters:
 - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 2. Comply with TIA-569-B.
- C. 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.
- D. Description: PVC, extruded and fabricated to required size and shape, and having snap-on cover, mechanically coupled connections, and plastic fasteners.
- E. 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.
- F. Solvent cements and adhesive primers shall have a VOC content of 510 and 550 g/L or less, respectively, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

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- G. Solvent cements and adhesive primers shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.6 BOXES, ENCLOSURES, AND CABINETS

- A. Manufacturers: Subject to compliance with requirements, 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. Adalet.
 2. Cooper Technologies Company; Cooper Crouse-Hinds.
 3. EGS/Appleton Electric.
 4. Erickson Electrical Equipment Company.
 5. Hoffman.
 6. Lamson & Sessions; Carlon Electrical Products.
 7. Milbank Manufacturing Co.
 8. Molex.
 9. Mono-Systems, Inc.
 10. O-Z/Gedney.
 11. Quazite:Hubbell Power Systems, Inc.
 12. RACO; Hubbell.
 13. Robroy Industries.
 14. Spring City Electrical Manufacturing Company.
 15. Stahlin Non-Metallic Enclosures.
 16. Thomas & Betts Corporation.
 17. Wiremold / Legrand.
- B. General Requirements for Boxes, Enclosures, and Cabinets:
1. Comply with TIA-569-B.
 2. Boxes, enclosures and cabinets installed in wet locations shall be listed for use in wet locations.
- C. Sheet-Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.
- D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy aluminum, Type FD, with gasketed cover.
- E. Box extensions used to accommodate new building finishes shall be of same material as recessed box.

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- F. Metal Floor Boxes:
 - 1. Material: Cast metal or sheet metal.
 - 2. Type: Fully adjustable, Semi-adjustable.
 - 3. Shape: Rectangular.
 - 4. Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70.
 - 5. Shape: Rectangular. Qualified testing agency, and marked for intended location and application.

- G. Nonmetallic Floor Boxes: Nonadjustable, round or rectangular.
 - 1. Listing and Labeling: 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.

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

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

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

- K. Gangable boxes are prohibited.

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

- M. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1, Type 3R, Type 4 and Type 12, (dependent on environmental conditions), with continuous-hinge cover with flush latch unless otherwise indicated.
 - 1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
 - 2. Nonmetallic Enclosures:
 - a. Material: Plastic, Fiberglass.
 - b. Finished inside with radio-frequency-resistant paint.
 - 3. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

- N. Cabinets:
 - 1. NEMA 250, Type 1, Type 3R and Type 12, (dependent on environmental conditions), galvanized- steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
 - 2. Hinged door in front cover with flush latch and concealed hinge.
 - 3. Key latch to match panelboards.
 - 4. Metal barriers to separate wiring of different systems and voltage.
 - 5. Accessory feet where required for freestanding equipment.
 - 6. Nonmetallic cabinets shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.7 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND CABLING

- 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.
 3. Comply with TIA-569-B.
 4. Handholes/Manholes shall be traffic rated when installed in parking lots, access roads and streets.
- B. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel, fiberglass or a combination of the two.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Armorcast Products Company.
 - b. Carson Industries LLC.
 - c. NewBasis.
 - d. Oldcastle Precast, Inc; Christy Concrete Products.
 2. Standard: Comply with SCTE 77.
 3. Configuration: Designed for flush burial with open, closed, 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 (300 mm Wide by 600 mm Long) and Larger: Have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.8 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.

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2. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
3. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

PART 3 EXECUTION

3.1 PATHWAY APPLICATION

- A. Outdoors: Apply pathway products as specified below unless otherwise indicated:
 1. Exposed Conduit: GRC, IMC, RNC, Type EPC-40-PVC, RNC, Type EPC-80-PVC.
 2. Concealed Conduit, Aboveground: GRC, IMC, EMT, RNC, Type EPC-40-PVC.
 3. Underground Conduit: RNC, Type EPC-40-PVC, Type EPC-80-PVC, direct buried concrete encased.
 4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC, LFNC.
 5. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R, Type 4.
- B. Indoors: Apply pathway products as specified below unless otherwise indicated:
 1. Exposed, Not Subject to Physical Damage: EMT, ENT or RNC.
 2. Exposed, Not Subject to Severe Physical Damage: EMT, RNC identified for such use.
 3. Exposed and Subject to Severe Physical Damage: GRC, IMC. Pathway locations include the following:
 - a. Loading dock.
 - b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
 - c. Mechanical rooms.
 - d. Gymnasiums
 4. Concealed in Ceilings and Interior Walls and Partitions: EMT, ENT or RNC, Type EPC-40-PVC.
 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, IMC.
 7. Pathways for Optical-Fiber or Communications Cable in Spaces Used for Environmental Air: Plenum-type, optical-fiber-cable pathway, Plenum-type, communications-cable pathway, EMT.
 8. Pathways for Optical-Fiber or Communications-Cable Risers in Vertical Shafts: Riser-type, optical-fiber-cable pathway, Riser-type, communications-cable pathway, EMT.

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9. Pathways for Concealed General Purpose Distribution of Optical-Fiber or Communications Cable: General-use, optical-fiber-cable pathway, Riser-type, optical-fiber-cable pathway, Plenum-type, optical-fiber-cable pathway, General-use, communications-cable pathway, Riser-type, communications-cable pathway Plenum-type, communications-cable pathway, EMT.
 10. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel, nonmetallic in institutional and commercial kitchens and damp or wet locations.
- C. Minimum Pathway Size: 3/4-inch (21-mm) trade size. Minimum size for optical-fiber cables is 1 inch (27 mm).
- 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 setscrew or compression, steel, cast-metal fittings. Comply with NEMA FB 2.10.
 4. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.
- E. 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).

3.2 INSTALLATION

- A. Comply with NECA 1, NECA 101, and TIA-569-B for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum pathways. Comply with NFPA 70 limitations for types of pathways allowed in specific occupancies and number of floors.
- B. Keep pathways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal pathway runs above water and steam piping.
- C. Complete pathway installation before starting conductor installation.
- D. Comply with requirements in Section 26 0529 "Hangers and Supports for Electrical Systems" for hangers and supports.
- E. Arrange stub-ups so curved portions of bends are not visible above finished slab.

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- F. Install no more than the equivalent of three 90-degree bends in any conduit run except for communications wiring conduits for which only two 90-degree bends are allowed. Support within 12 inches (300 mm) of changes in direction.
- G. Conceal conduit and EMT within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
- H. Support conduit within 12 inches (300 mm) of enclosures to which attached.
- I. Pathways Embedded in Slabs:
 - 1. Run conduit larger than 1-inch (27-mm) trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure pathways to reinforcement at maximum 10-foot (3-m) intervals.
 - 2. Arrange pathways to cross building expansion joints at right angles with expansion fittings.
 - 3. Arrange pathways to keep a minimum of 1 inch (25 mm), 2 inches (50 mm) of concrete cover in all directions.
 - 4. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.
 - 5. Change from ENT to RNC, Type EPC-40-PVC, GRC or IMC before rising above floor.
- J. Stub-ups to Above Recessed Ceilings:
 - 1. Use EMT, IMC, or RMC for pathways.
 - 2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.
- K. 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.
- L. Coat field-cut threads on PVC-coated pathway with a corrosion-preventing conductive compound prior to assembly.
- M. 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.
- N. Install pathways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.
- O. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to conduit assembly to assure a continuous ground path.
- P. Cut conduit perpendicular to the length. For conduits of 2-inch (53-mm) trade size and larger, use roll cutter or a guide to ensure cut is straight and perpendicular to the length.
- Q. Install pull wires in empty pathways. Use polypropylene or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of pull wire. Cap underground pathways designated as spare above grade alongside pathways in use.

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- R. Surface Pathways:
1. Install surface pathway for surface electrical outlet boxes only where indicated on Drawings.
 2. Install surface pathway with a minimum 2-inch (50-mm) radius control at bend points.
 3. Secure surface pathway with screws or other anchor-type devices at intervals not exceeding 48 inches (1200 mm) and with no less than two supports per straight pathway section. Support surface pathway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.
- S. Pathways for Optical-Fiber and Communications Cable: Install pathways, metal and nonmetallic, rigid and flexible, as follows:
1. 1-Inch (27-mm) Trade Size and Larger: Install pathways in maximum lengths of 75 feet (23 m).
 2. Install with a maximum of two 90-degree bends or equivalent for each length of pathway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.
- T. 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.
- U. 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.
- V. Comply with manufacturer's written instructions for solvent welding PVC conduit and fittings.
- W. 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.

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- 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.
- X. 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.
- Y. 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 rain-tight connection between box and cover plate or supported equipment and box.
- Z. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.
- AA. 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.
- BB. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.
- CC. Set metal floor boxes level and flush with finished floor surface.
- DD. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.3 INSTALLATION OF UNDERGROUND CONDUIT

- A. Direct-Buried Conduit:
 - 1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Division 31 for pipe less than 6 inches (150 mm) in nominal diameter.
 - 2. Install backfill as specified in Division 31.
 - 3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches

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- (300 mm) of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Division 31.
4. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through floor unless otherwise indicated. Encase elbows for stub-up ducts throughout the 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 26 0553 "Identification for Electrical Systems."

3.4 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 and in accordance within manufacturer's guidelines.
- E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in enclosure.
- F. Field cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

3.5 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRONIC SAFETY AND SECURITY PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Division 26.

3.6 FIRESTOPPING

- A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Division 07.

3.7 PROTECTION

- A. Protect coatings, finishes, and cabinets from damage and deterioration.
 - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
 - 2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION

**SECTION 28 0544 - SLEEVES AND SLEEVE SEALS FOR ELECTRONIC SAFETY AND SECURITY
PATHWAYS AND CABLING**

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Refer to Technology responsibility matrix, located on plan set for further information.
- B. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- C. State of NM DoIT – Standard for Building and Campus Distribution Systems

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. Silicone sealants.
- B. Related Requirements:
 - 1. Section 07 8413 "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.
 - 2. Penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies and smoke barriers, with and without penetrating items.

1.3 ACTION SUBMITTAL

- A. Product Data: For each type of product.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: **Cabling Installer must have personnel certified by BICSI on staff.**
 - 1. Layout Responsibility: Preparation of Shop Drawings and Cabling Administration Drawings, Cabling Administration Drawings, and field testing program development by an RCDD.

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2. Installation Supervision: Installation shall be under the direct supervision of Registered Technician, or Level 2 Installer, who shall be present at all times when Work of this Section is performed at Project site.
 3. Testing Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.
- B. Testing Agency Qualifications: An NRTL.
1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

1.5 QUALIFICATIONS

- A. Communications Cabling: The Contractor shall have (5) five years of documented experience performing cable placement, splicing, termination, connecting, and testing for each of the media types and (3) three years of applicable experience with the proposed system manufacturer. In the case of newer technologies that do not have a (3) three year history, the Contractor shall have documented experience for at least half of the lifetime of the new technology. The approved contractor shall, at a minimum, maintain a ratio of one manufacturer or BICSI certified installer for every two non-certified installers assigned to the project.
- B. The contractor shall have on staff a BICSI Certified RCDD as a permanent employee. This staff member shall have been on staff for a minimum of (1) one year prior to the date of this projects release for bid.
- C. The contractor shall have on staff at least (1) one BICSI Certified Technician and this staff member shall have been a full time employee for no less than (1) one year prior to the date of this projects release for bid. A BICSI Certified Technician shall be employed as the on-site Field Supervisor for this project.
- D. The contractor shall provide resumes for the Project Manager, Supervisors and any skilled technicians or installers. Each resume shall include applicable certification documents provided by the manufacturer or BICSI.
1. Project Manager, Supervisors, and Principal Skilled Technicians: minimum of (5) five years' experience in like work.
 2. Category 6 Unshielded Twisted Pair and Fiber Optic Cable Technicians: documented training, licensing, and/or certification for the types of media specified, as applicable as well as certification from the manufacturer of the solution chosen by the owner.

1.6 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer, qualified layout technician, installation supervisor, field inspector and company. The contractor shall provide resumes for the Project Manager, Supervisors and any skilled technicians or installers. Each resume shall include applicable certification documents provided by the manufacturer or BICSI.
1. Project Manager, installation supervisor, and Principal Skilled Technicians: As a minimum be required to have no less than (5) five years' experience in like work.

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2. The Company/Contractor proposing shall provide historical data confirming the company has a minimum of (5) five years applicable experience.
 3. The Company/Contractor shall have a minimum of (3) three projects of similar size and type within the last (2) years. References for all submitted projects are required to assist with the evaluation.
- B. Category 6 Unshielded Twisted Pair and Fiber Optic Cable Technicians: Documented training, licensing, and/or certification for the types of media specified, as applicable as well as certification from the manufacturer of the solution chosen by the owner.
- C. Source quality-control reports.
- D. Field quality-control reports.

PART 2 PRODUCTS

2.1 SLEEVES

- A. Wall Sleeves:
1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.
 2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.
- B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch (0.6-mm) 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 (1270 mm) and with no side larger than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
 - b. For sleeve cross-section rectangle perimeter 50 inches (1270 mm) or more and one or more sides larger than 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

2.2 SLEEVE-SEAL SYSTEMS

- A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and pathway or cable.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work include the following:
 - a. Advance Products & Systems, Inc.
 - b. CALPICO, Inc.
 - c. Metraflex Company (The).
 - d. Pipeline Seal and Insulator, Inc.
 - e. Proco Products, Inc.
 2. Sealing Elements: EPDM, Nitrile (Buna N) rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
 3. Pressure Plates: Carbon steel, Plastic, Stainless steel.
 4. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, Stainless steel of length required to secure pressure plates to sealing elements.

2.3 SLEEVE-SEAL FITTINGS

- A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber waterstop collar with center opening to match piping OD.
1. Manufacturers: Subject to compliance with requirements, 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:
 - a. Presealed Systems.

2.4 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.
 2. Sealant shall have VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 3. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- B. Silicone Foams: Multicomponent, silicone-based, liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

PART 3 EXECUTION

3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

- A. Comply with NECA 1.
- B. Comply with NEMA VE 2 for cable tray and cable penetrations.
- C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:
 - 1. Interior Penetrations of Non-Fire-Rated Walls and Floors:
 - a. Seal annular space between sleeve and 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 (6.4-mm) 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 (50 mm) 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, cast-iron pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) 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 (25-mm) annular clear space between pathway or cable and sleeve for installing sleeve-seal system.

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at 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.

3.3 SLEEVE-SEAL-FITTING INSTALLATION

- A. Install sleeve-seal fittings in new walls and slabs as they are constructed.
- B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.
- C. Secure nailing flanges to concrete forms.
- D. Using grout, seal the space around outside of sleeve-seal fittings.

END OF SECTION

SECTION 28 1300 - ACCESS CONTROL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. State of NM DoIT – Standard for Building and Campus Distribution Systems
- C. Division 08 – Door Hardware Coordinate with Door Hardware Specifier

1.2 SUMMARY

- A. Section Includes:
 - 1. Security access central-control station.
 - 2. One or more security access networked workstations.
 - 3. Security access operating system and application software.
 - 4. Security access controllers connected to high-speed electronic-data transmission network.
- B. Related Requirements:
 - 1. 27 0526 Grounding and Bonding for Communications Systems
 - 2. 27 0528 Pathways for Communications Systems
 - 3. 27 0544 Sleeves and Sleeve Seals for Communications Pathways and Cabling
 - 4. 28 2000 Video Surveillance
 - 5. 28 3100 Intrusion Detection
 - 6. 28 3111 Fire Detection and Alarm

1.3 DEFINITIONS

- A. Credential: Data assigned to an entity and used to identify that entity.
- B. DTS: Digital Termination Service. A microwave-based, line-of-sight communication provided directly to the end user.
- C. Identifier: A credential card; keypad personal identification number; or code, biometric characteristic, or other unique identification entered as data into the entry-control database for the purpose of identifying an individual. Where this term is presented with an initial capital letter, this definition applies.

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- D. Location: A Location on the network having a workstation-to-controller communications link, with additional controllers at the Location connected to the workstation-to-controller link with a TIA 485-A communications loop. Where this term is presented with an initial capital letter, this definition applies.
- E. Workstation: Personal computer. Applies to the central station, workstations, and file servers.
- F. RAS: Remote access services.
- G. RF: Radio frequency.
- H. ROM: Read-only memory. ROM data are maintained through losses of power.
- I. TCP/IP: Transport control protocol/Internet protocol.
- J. TWAIN: Technology without an Interesting Name. A programming interface that lets a graphics application, such as an image editing program or desktop publishing program, activate a scanner, frame grabber, or other image-capturing device.
- K. WMP: Windows media player.
- L. Wiegand: Patented magnetic principle that uses specially treated wires embedded in the credential card.
- M. WYSIWYG: What You See Is What You Get. Text and graphics appear on the screen the same as they will in print.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Reference each product to a location on Drawings. Test and evaluation data presented in Product Data shall comply with SIA BIO-01.
- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - 1. Diagrams for cable management system.
 - 2. System labeling schedules, including electronic copy of labeling schedules that are part of the cable and asset identification system of the software specified in Parts 2 and 3.
 - 3. Wiring Diagrams. For power, signal, and control wiring. Show typical wiring schematics including the following:
 - a. Workstation outlets, jacks, and jack assemblies.
 - b. Patch cords.
 - c. Patch panels.
 - 4. Cable Administration Drawings: As specified in "Identification" Article.
 - 5. Battery and charger calculations for central station, workstations, and controllers.

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- C. Product Schedules.
- D. Samples: For workstation outlets, jacks, jack assemblies, and faceplates. For each exposed product and for each color and texture specified.

1.5 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For security system to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - 1. Workstation operating system documentation.
 - 2. Workstation installation and operating documentation, manuals, and software for the workstation and all installed peripherals. Software shall include system restore, emergency boot diskettes, and drivers for all installed hardware. Provide separately for each workstation.
 - 3. Hard copies of manufacturer's specification sheets, operating specifications, design guides, user's guides for software and hardware, and PDF files on USB or cloud media of the hard-copy submittal.
 - 4. System installation and setup guides with data forms to plan and record options and setup decisions.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Laser Printers: Three toner cassettes and one replacement drum unit.
 - 2. Credential card blanks, ready for printing. Include enough credential cards for all personnel to be enrolled at the site plus an extra **25** percent for future use.
 - 3. Fuses of all kinds, power and electronic, equal to **10** percent of amount installed for each size used, but no fewer than three units.

1.8 QUALITY ASSURANCE

- A. Installer Qualifications: An employer of workers trained and approved by manufacturer.
 - 1. Cable installer must have on staff an RCDD certified by Building Industry Consulting Service International.
- B. Source Limitations: Obtain central station, workstations, controllers, Identifier readers, and all software through one source from single manufacturer.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Central Station, Workstations, and Controllers:

1. Store in temperature- and humidity-controlled environment in original manufacturer's sealed containers. Maintain ambient temperature between 50 and 85 deg F, and not more than 80 percent relative humidity, noncondensing.
2. Open each container; verify contents against packing list; and file copy of packing list, complete with container identification, for inclusion in operation and maintenance data.
3. Mark packing list with the same designations assigned to materials and equipment for recording in the system labeling schedules that are generated by software specified in "Cable and Asset Management Software" Article.
4. Save original manufacturer's containers and packing materials and deliver as directed under provisions covering extra materials.

1.10 PROJECT CONDITIONS

A. Environmental Conditions: System shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:

1. Control Station: Rated for continuous operation in ambient conditions of 60 to 85 deg F and a relative humidity of 20 to 80 percent, noncondensing.
2. Indoor, Controlled Environment: NEMA 250, Type 1 enclosure. System components, except the central-station control unit, installed in temperature-controlled indoor environments shall be rated for continuous operation in ambient conditions of 36 to 122 deg F dry bulb and 20 to 90 percent relative humidity, noncondensing.
3. Indoor, Uncontrolled Environment: NEMA 250, Type 3R enclosures. System components installed in non-temperature-controlled indoor environments shall be rated for continuous operation in ambient conditions of 0 to 122 deg F dry bulb and 20 to 90 percent relative humidity, noncondensing.
4. Outdoor Environment: NEMA 250, NEMA 250, Type 4 enclosures. System components installed in locations exposed to weather shall be rated for continuous operation in ambient conditions of minus 30 to plus 122 deg F dry bulb and 20 to 90 percent relative humidity, condensing. Rate for continuous operation where exposed to rain as specified in NEMA 250, winds up to 85 mph and snow cover up to 24 inches thick.
5. Hazardous Environment: System components located in areas where fire or explosion hazards may exist because of flammable gases or vapors, flammable liquids, combustible dust, or ignitable fibers shall be rated, listed, and installed according to NFPA 70.
6. Corrosive Environment: For system components subjected to corrosive fumes, vapors, and wind-driven salt spray in coastal zones, provide NEMA 250, Type 4X enclosures.

PART 2 - PRODUCTS

2.1 ACCESS CONTROL SOFTWARE

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

2.2 DESCRIPTION

- A. Security Access System: PC-based central station, one or more networked PC-based workstations, and field-installed controllers, connected by a high-speed electronic-data transmission network.
- B. System Software: Based on 32 -bit, Microsoft Windows central-station, workstation operating system, server operating system, and application software. Software shall have the following capabilities:
1. Multiuser and multitasking to allow for independent activities and monitoring to occur simultaneously at different workstations.
 2. Graphical user interface to show pull-down menus and a menu-tree format that complies with interface guidelines of Microsoft Windows.
 3. System license for the entire system including capability for future additions that are within the indicated system size limits specified in this Section.
 4. Open-architecture system that allows importing and exporting of data and interfacing with other systems that are compatible with Microsoft Windows.
 5. Password-protected operator login and access.
 6. Open-database-connectivity compliant.
 7. Software and system shall perform "Lock-down" functions.
- C. Network connecting the central station and workstations shall be a LAN, WAN using Microsoft Windows-based TCP/IP with a capacity of connecting up to 99 workstations. System shall be portable across multiple communication platforms without changing system software.
- D. Network(s) connecting PCs and controllers shall consist of one or more of the following:
1. Local area, IEEE 802.3 Fast Ethernet Gigabit-Ethernet, 100 BASE-TX, star topology network based on TCP/IP.
 2. Direct-connected, RS-232 cable from the COM port of the central station to the first controller, then RS-485 cable to interconnect the remaining controllers at that Location.
 3. Dial-up and cable modem connection using a standard cable or dial-up telephone line.
- E. Front vestibule doors and gym, main, entrance doors to be "wired" for Lock down events.

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- F. Lock sets shall be “Fail Secure” lock sets.
- G. Contractor is responsible for ensuring that software, locks sets, controllers, push button and additional control panel, (if applicable), are compatible and are able to perform a lock down function.

2.3 OPERATION

- A. Security access system shall use a single database for access-control and credential-creation functions.
- B. Contractor is responsible for providing and installing a complete “turn-key” Access control system that meets or exceeds the specifications listed below. Contractor is to provide and install a new system for the front vestibule doors and gym main entrance doors and is to be wired. New Access control system is to perform “Lockdown” function.
- C. Distributed Processing: A fully distributed processing system.
 - 1. Access-control information, including time, date, valid codes, access levels, and similar data, shall be downloaded to controllers so each controller can make access-control decisions.
 - 2. Intermediate controllers for access control are prohibited.
 - 3. In the event that communications with the central controller are lost, controllers shall automatically buffer event transactions until communications are restored, at which time buffered events shall be uploaded to the central station.
- D. Number of Locations:
 - 1. Support at least 32,000 separate Locations using a single PC with combinations of direct-connect, dial-up, or TCP/IP LAN connections to each Location.
 - 2. Each Location shall have its own database and history in the central station.
 - 3. Locations may be combined to share a common database.
- E. Data Capacity:
 - 1. 130 different card-reader formats.
 - 2. 999 comments.
 - 3. 48 graphic file types for importing maps.
- F. Location Capacity:
 - 1. 128 reader-controlled doors.
 - 2. 50,000 total-access credentials.
 - 3. 2048 supervised alarm inputs.
 - 4. 2048 programmable outputs.
 - 5. 32,000 custom action messages per Location to instruct operator on action required when alarm is received.

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- G. System Network Requirements:
1. System components shall be interconnected and shall provide automatic communication of status changes, commands, field-initiated interrupts, and other communications required for proper system operation.
 2. Communication shall not require operator initiation or response and shall return to normal after partial- or total-network interruption such as power loss or transient upset.
 3. System shall automatically annunciate communication failures to the operator and shall identify the communications link that has experienced a partial or total failure.
 4. Communications controller may be used as an interface between the central-station display systems and the field device network. Communications controller shall provide functions required to attain the specified network communications performance.
- H. Central station shall provide operator interface, interaction, display, control, and dynamic and real-time monitoring. Central station shall control system networks to interconnect all system components, including workstations and field-installed controllers.
- I. Field equipment shall include controllers, sensors, and controls.
1. Controllers shall serve as an interface between the central station and sensors and controls.
 2. Data exchange between the central station and the controllers shall include down-line transmission of commands, software, and databases to controllers.
 3. The up-line data exchange from the controller to the central station shall include status data such as intrusion alarms, status reports, and entry-control records.
 4. Controllers are classified as alarm-annunciation or entry-control type.
- J. System Response to Alarms:
1. Field device network shall provide a system end-to-end response time of one second(s) or less for every device connected to the system.
 2. Alarms shall be annunciated at the central station within one second of the alarm occurring at a controller or at a device controlled by a local controller, and within 100 ms if the alarm occurs at the central station.
 3. Alarm and status changes shall be displayed within 100 ms after receipt of data by the central station.
 4. All graphics shall be displayed, including graphics-generated map displays, on the console monitor within five seconds of alarm receipt at the security console.
 5. This response time shall be maintained during system heavy load.
- K. False-Alarm Reduction: The design of the central station and controllers shall contain features to reduce false alarms. Equipment and software shall comply with SIA CP-01.

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- L. Error Detection:
 - 1. Use a cyclic code method to detect single- and double-bit errors, burst errors of eight bits or fewer, and at least 99 percent of all other multibit and burst errors between controllers and the central station.
 - 2. Interactive or product error-detection codes alone will not be acceptable.
 - 3. A message shall be in error if one bit is received incorrectly.
 - 4. Retransmit messages with detected errors.
 - 5. Allow for an operator-assigned two-digit decimal number to each communications link representing the number of retransmission attempts.
 - 6. Central station shall print a communication failure alarm message when the number of consecutive retransmission attempts equals the assigned quantity.
 - 7. Monitor the frequency of data transmission failure for display and logging.
- M. Data Line Supervision: System shall initiate an alarm in response to opening, closing, shorting, or grounding of data transmission lines.
- N. Door Hardware Interface:
 - 1. Comply with requirements in Section 087100 "Door Hardware" and Section 087111 "Door Hardware (Descriptive Specification)" for door hardware required to be monitored or controlled by the security access system.
 - 2. Electrical characteristics of controllers shall match the signal and power requirements of door hardware.

2.4 APPLICATION SOFTWARE

- A. System Software: Based on 64 Microsoft Windows central-station and workstation operating system and application software.
 - 1. Multiuser multitasking shall allow independent activities and monitoring to occur simultaneously at different workstations.
 - 2. Graphical user interface shall show pull-down menus and a menu-tree format.
 - 3. Capability for future additions within the indicated system size limits.
 - 4. Open architecture that allows importing and exporting of data and interfacing with other systems that are compatible with operating system.
 - 5. Password-protected operator login and access.
- B. Peer Computer Control Software: Detect a failure of a central computer and cause the other central computer to assume control of all system functions without interruption of operation. Both central computers shall have drivers to support this mode of operation.
- C. Application Software: Interface between the alarm annunciation and entry-control controllers to monitor sensors and DTS links, operate displays, report alarms, generate reports, and help train system operators.

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1. Reside at the central station, workstations, and controllers as required to perform specified functions.
 2. Operate and manage peripheral devices.
 3. Manage files for disk I/O, including creating, deleting, and copying files; and automatically maintain a directory of all files, including size and location of each sequential and random-ordered record.
 4. Import custom icons into graphics to represent alarms and I/O devices.
 5. Globally link I/O so that any I/O can link to any other I/O within the same Location without requiring interaction with the host workstation. This operation shall be at the controller.
 6. Globally code I/O links so that any access-granted event can link to any I/O with the same Location without requiring interaction with the host workstation. This operation shall be at the controller.
 7. Messages from workstation to controllers and controllers to controllers shall be on a polled network that utilizes check summing and acknowledgment of each message. Communication shall be automatically verified, buffered, and retransmitted if message is not acknowledged.
 8. Selectable poll frequency and message time-out settings shall handle bandwidth and latency issues for TCP/IP, RF, and other workstation-to-controller communications methods by changing the polling frequency and the amount of time the system waits for a response.
 9. Automatic and encrypted backups for database and history backups shall be automatically stored at the central-control workstation and any other selected workstation and encrypted with a nine-character alphanumeric password that must be used to restore or read data contained in backup.
 10. Operator audit trail for recording and reporting all changes made to database and system software.
 11. Support network protocol and topology, TCP/IP, Novel Netware, Digital Pathworks, Banyan Vines, LAN/WAN, and RAS.
- D. Workstation Software:
1. Password levels shall be individually customized at each workstation to allow or disallow operator access to program functions for each Location.
 2. Workstation event filtering shall allow user to define events and alarms that will be displayed at each workstation. If an alarm is unacknowledged (not handled by another workstation) for a preset amount of time, the alarm will automatically appear on the filtered workstation.
- E. Controller Software:
1. Controllers shall operate as autonomous, intelligent processing units.
 - a. Controllers shall make decisions about access control, alarm monitoring, linking functions, and door-locking schedules for their operation, independent of other system components.
 - b. Controllers shall be part of a fully distributed processing-control network.

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- c. The portion of the database associated with a controller, and consisting of parameters, constraints, and the latest value or status of points connected to that controller, shall be maintained in the controller.
2. The following functions shall be fully implemented and operational within each controller:
 - a. Monitoring inputs.
 - b. Controlling outputs.
 - c. Automatically reporting alarms to the central station.
 - d. Reporting of sensor and output status to the central station on request.
 - e. Maintaining real time, automatically updated by the central station at least once a day.
 - f. Communicating with the central station.
 - g. Executing controller resident programs.
 - h. Diagnosing.
 - i. Downloading and uploading data to and from the central station.
3. Controller Operations at a Location:
 - a. Up to 64 controllers connected to TIA 485-A communications loop. Globally operating I/O linking and anti-passback functions between controllers within the same Location without central-station or workstation intervention. Linking and anti-passback shall remain fully functional within the same Location even when the central station or workstations are off-line.
 - b. In the event of communication failure between the central station and a Location, there shall be no degradation in operations at the controllers at that Location. Controllers at each Location shall be connected to a memory buffer with a capacity to store up to 10,000 events; there shall be no loss of transactions in system history files until the buffer overflows.
 - c. Buffered events shall be handled in a first-in-first-out mode of operation.
4. Individual Controller Operation:
 - a. Controllers shall transmit alarms, status changes, and other data to the central station when communications circuits are operable. If communications are not available, controllers shall function in a stand-alone mode; operational data, including the status and alarm data normally transmitted to the central station, shall be stored for later transmission to the central station. Storage capacity for the latest 1024 events shall be provided at each controller.
 - b. Card-reader ports of a controller shall be custom configurable for at least 120 different card-reader or keypad formats. Multiple reader or keypad formats may be used simultaneously at different controllers or within the same controller.
 - c. Controllers shall provide a response to card readers or keypad entries in less than 0.25 seconds, regardless of system size.
 - d. Controllers that are reset, or powered up from a nonpowered state, shall automatically request a parameter download and reboot to their proper working state. This shall happen without any operator intervention.
 - e. Initial Startup: When controllers are brought on-line, database parameters shall be automatically downloaded to them. After initial download is completed, only database changes shall be downloaded to each controller.

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- f. On failure for any reason, controllers shall perform an orderly shutdown and force controller outputs to a predetermined failure-mode state, consistent with the failure modes shown and the associated control device.
 - g. After power is restored, following a power failure, startup software shall initiate self-test diagnostic routines, after which controllers shall resume normal operation.
 - h. After controller failure, if the database and application software are no longer resident, controllers shall not restart but shall remain in the failure mode until repaired. If database and application programs are resident, controllers shall immediately resume operation. If not, software shall be restored automatically from the central station.
 5. Communications Monitoring:
 - a. System shall monitor and report status of TIA 485-A communications loop of each Location.
 - b. Communication status window shall display which controllers are currently communicating, a total count of missed polls since midnight, and which controller last missed a poll.
 - c. Communication status window shall show the type of CPU, the type of I/O board, and the amount of RAM for each controller.
 6. Operating systems shall include a real-time clock function that maintains seconds, minutes, hours, day, date, and month. The real-time clock shall be automatically synchronized with the central station at least once a day to plus or minus 10 seconds. The time synchronization shall be automatic, without operator action and without requiring system shutdown.
- F. workstation-to-Controller Communications:
1. Central-station or workstation communications shall use the following:
 - a. Direct connection using serial ports of the workstation.
 - b. TCP/IP LAN interface cards.
 - c. Dial-up or cable modems for connections to Locations.
 2. Each serial port used for communications shall be individually configurable for "direct communications," "modem communications incoming and outgoing," or "modem communications incoming only," or as an ASCII output port. Serial ports shall have adjustable data transmission rates and shall be selectable under program control.
 3. Use multiport communications board if more than two serial ports are needed.
 - a. Use a 4-, 8-, or 16-serial port configuration that is expandable to 32- or 64-serial ports.
 - b. Connect the first board to an internal PCI bus adapter card.
 4. Direct serial, TCP/IP, and dial-up, cable, or satellite communications shall be alike in the monitoring or control of the system except for the connection that must first be made to a dial-up or voice-over IP Location.
 5. TCP/IP network interface card (NIV) shall have an option to set the poll-frequency and message-response time-out settings.

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6. Workstation-to-controller and controller-to-controller communications (direct, dial-up, or TCP/IP) shall use a polled-communication protocol that checks sum and acknowledges each message. All communications in this subparagraph shall be verified and buffered, and retransmitted if not acknowledged.
- G. Direct Serial or TCP/IP workstation-to-Controller Communications:
1. Communication software on the workstation shall supervise the workstation-to-controller communications link.
 2. Loss of communications to any controller shall result in an alarm at all workstations running the communication software.
 3. When communications are restored, all buffered events shall automatically upload to the workstation, and any database changes shall be automatically sent to the controller.
- H. Broadband Workstation-to-Controller Communications:
1. Communication software on the workstation shall supervise the workstation-to-controller communications link during dial-up modem connect times.
 2. Communication software shall be programmable to routinely poll each of the remote dial-up or cable modem Locations, collecting event logs and verifying phone lines at operator-selectable time intervals for each Location.
 3. System shall be programmable for dialing and connecting to all dial-up or cable modem Locations and for retrieving the accrued history transactions on an automatic basis as often as once every 10 minutes and up to once every 9999 minutes.
 4. Failure to communicate to a dial-up Location three times in a row shall result in an alarm at the workstation.
 5. Time offset capabilities shall be present so that Locations in a different geographical time zone than the host workstation will be set to, and maintained at, the proper local time. This feature shall allow for geographical time zones that are ahead of or behind the host workstation.
 6. The controller connected to a dial-up or cable modem shall automatically buffer all normal transactions until its buffer reaches 80 percent of capacity. When the transaction buffer reaches 80 percent, the controller shall automatically initiate a call to the central station and upload all transactions.
 7. Alarms shall be reported immediately.
 8. Dial-up or cable modems shall be provided by manufacturer of the system. Modems used at the controller shall be powered by the controller. Power to the modem shall include battery backup if the controller is so equipped.
- I. Controller-to-Controller Communications:
1. TIA 485-A, four-wire, point-to-point, regenerative (repeater) communications network methodology.
 2. TIA 485-A communications signal shall be regenerated at each controller.
- J. Database Downloads:

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1. All data transmissions from workstations to a Location, and between controllers at a Location, shall include a complete database checksum to check the integrity of the transmission. If the data checksum does not match, a full data download shall be automatically retransmitted.
2. If a controller is reset for any reason, it shall automatically request and receive a database download from the workstation. The download shall restore data stored at the controller to their normal working state and shall take place with no operator intervention.

K. Operator Interface:

1. Inputs in system shall have two icon representations, one for the normal state and one for the abnormal state.
2. When viewing and controlling inputs, displayed icons shall automatically change to the proper icon to display the current system state in real time. Icons shall also display the input's state, whether armed or bypassed, and if the input is in the armed or bypassed state due to a time zone or a manual command.
3. Outputs in system shall have two icon representations, one for the secure (locked) state and one for the open (unlocked) state.
4. Icons displaying status of the I/O points shall be constantly updated to show their current real-time condition without prompting by the operator.
5. The operator shall be able to scroll the list of I/Os and press the appropriate toolbar button, or right click, to command the system to perform the desired function.
6. Graphic maps or drawings containing inputs, outputs, and override groups shall include the following:
 - a. Database to import and store full-color maps or drawings and allow for input, output, and override group icons to be placed on maps.
 - b. Maps to provide real-time display animation and allow for control of points assigned to them.
 - c. System to allow inputs, outputs, and override groups to be placed on different maps.
 - d. Software to allow changing the order or priority in which maps will be displayed.
7. Override Groups Containing I/Os:
 - a. System shall incorporate override groups that provide the operator with the status and control over user-defined "sets" of I/Os with a single icon.
 - b. Icon shall change automatically to show the live summary status of points in that group.
 - c. Override group icon shall provide a method to manually control or set to time-zone points in the group.
 - d. Override group icon shall allow the expanding of the group to show icons representing the live status for each point in the group, individual control over each point, and the ability to compress the individual icons back into one summary icon.
8. Schedule Overrides of I/Os and Override Groups:

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- a. To accommodate temporary schedule changes that do not fall within the holiday parameters, the operator shall have the ability to override schedules individually for each input, output, or override group.
 - b. Each schedule shall be composed of a minimum of two dates with separate times for each date.
 - c. The first time and date shall be assigned the override state that the point shall advance to when the time and date become current.
 - d. The second time and date shall be assigned the state that the point shall return to when the time and date become current.
9. Copy command in database shall allow for like data to be copied and then edited for specific requirements, to reduce redundant data entry.
- L. Operator Access Control:
1. Control operator access to system controls through three password-protected operator levels. System operators and managers with appropriate password clearances shall be able to change operator levels for operators.
 2. Three successive attempts by an operator to execute functions beyond their defined level during a 24-hour period shall initiate a software tamper alarm.
 3. A minimum of 1000 unique user accounts shall be available with the system software. System shall display the operator's name or initials in the console's first field. System shall print the operator's name or initials, action, date, and time on the system printer at login and logoff.
 4. The password shall not be displayed or printed.
 5. Each password shall be definable and assignable for the following:
 - a. Selected commands to be usable.
 - b. Access to system software.
 - c. Access to application software.
 - d. Individual zones that are to be accessed.
 - e. Access to database.
- M. Operator Commands:
1. Command Input: Plain-language words and acronyms shall allow operators to use the system without extensive training or data-processing backgrounds. System prompts shall be a word, a phrase, or an acronym.
 2. Command inputs shall be acknowledged and processing shall start in not less than one second(s).
 3. Tasks that are executed by operator's commands shall include the following:
 - a. Acknowledge Alarms: Used to acknowledge that the operator has observed the alarm message.
 - b. Place Zone in Access: Used to remotely disable intrusion-alarm circuits emanating from a specific zone. System shall be structured so that console operator cannot disable tamper circuits.
 - c. Place Zone in Secure: Used to remotely activate intrusion-alarm circuits emanating from a specific zone.
 - d. System Test: Allows the operator to initiate a system-wide operational test.

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- e. Zone Test: Allows the operator to initiate an operational test for a specific zone.
 - f. Print reports.
 - g. Change Operator: Used for changing operators.
 - h. Security Lighting Controls: Allows the operator to remotely turn on or turn off security lights.
 - i. Display Graphics: Used to show any graphic displays implemented in the system. Graphic displays shall be completed within 20 seconds from time of operator command.
 - j. Run system tests.
 - k. Generate and format reports.
 - l. Request help with the system operation.
 - 1) Include in main menus.
 - 2) Provide unique, descriptive, context-sensitive help for selections and functions with the press of one function key.
 - 3) Provide navigation to specific topic from within the first help window.
 - 4) Help shall be accessible outside the application program.
 - m. Entry-Control Commands:
 - 1) Lock (secure) or unlock (open) each controlled entry and exit up to four times a day through time-zone programming.
 - 2) Arm or disarm each monitored input up to four times a day through time-zone programming.
 - 3) Enable or disable readers or keypads up to two times a day through time-zone programming.
 - 4) Enable or disable cards or codes up to four times a day per entry point through access-level programming.
4. Command Input Errors: Show operator input assistance when a command cannot be executed because of operator input errors. Assistance screen shall use plain-language words and phrases to explain why the command cannot be executed. Error responses that require an operator to look up a code in a manual or other document are not acceptable. Conditions causing operator assistance messages include the following:
- a. Command entered is incorrect or incomplete.
 - b. Operator is restricted from using that command.
 - c. Command addresses a point that is disabled or out of service.
 - d. Command addresses a point that does not exist.
 - e. Command is outside the system's capacity.
- N. Alarms:
- 1. System Setup:
 - a. Assign manual and automatic responses to incoming-point status change or alarms.
 - b. Automatically respond to input with a link to other inputs, outputs, or operator-response plans; unique sound with use of WAV files; and maps or images that graphically represent the point location.
 - c. Sixty-character message field for each alarm.

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- d. Operator-response-action messages shall allow message length of at least 65,000 characters, with database storage capacity of up to 32,000 messages. Setup shall assign messages to access point.
 - e. Secondary messages shall be assignable by the operator for printing to provide further information and shall be editable by the operator.
 - f. Allow 25 secondary messages with a field of four lines of 60 characters each.
 - g. Store the most recent 1000 alarms for recall by the operator using the report generator.
2. Software Tamper:
 - a. Annunciate a tamper alarm when unauthorized changes to system database files are attempted. Three consecutive unsuccessful attempts to log onto system shall generate a software tamper alarm.
 - b. Annunciate a software tamper alarm when an operator or other individual makes three consecutive unsuccessful attempts to invoke functions beyond the authorization level.
 - c. Maintain a transcript file of the last 5000 commands entered at each central station to serve as an audit trail. System shall not allow write access to system transcript files by any person, regardless of their authorization level.
 - d. Allow only acknowledgment of software tamper alarms.
 3. Read access to system transcript files shall be reserved for operators with the highest password authorization level available in system.
 4. Animated Response Graphics: Highlight alarms with flashing icons on graphic maps; display and constantly update the current status of alarm inputs and outputs in real time through animated icons.
 5. Alarm Handling: Each input may be configured so that an alarm cannot be cleared unless it has returned to normal, with options of requiring the operator to enter a comment about disposition of alarm. Allow operator to silence alarm sound when alarm is acknowledged.
 6. Alarm Automation Interface: High-level interface to central-station alarm automation software systems. Allows input alarms to be passed to and handled by automation systems in the same manner as burglar alarms, using a TIA 232-F ASCII interface.
 7. CCTV Alarm Interface: Allow commands to be sent to CCTV systems during alarms (or input change of state) through serial ports.
 8. Camera Control: Provides operator ability to select and control cameras from graphic maps.
- O. Alarm Monitoring: Monitor sensors, controllers, and DTS circuits and notify operators of an alarm condition. Display higher-priority alarms first and, within alarm priorities, display the oldest unacknowledged alarm first. Operator acknowledgment of one alarm shall not be considered acknowledgment of other alarms nor shall it inhibit reporting of subsequent alarms.

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1. Displayed alarm data shall include type and location of alarm. Printed alarm data shall include type of alarm, location of alarm, date and time (to nearest second) of occurrence, and operator responses.
2. Maps shall automatically display the alarm condition for each input assigned to that map if that option is selected for that input location.
3. Alarms initiate a status of "pending" and require the following two handling steps by operators:
 - a. First Operator Step: "Acknowledged." This action shall silence sounds associated with the alarm. The alarm remains in the system "Acknowledged" but "Un-Resolved."
 - b. Second Operator Step: Operators enter the resolution or operator comment, giving the disposition of the alarm event. The alarm shall then clear.
4. Each workstation shall display the total pending alarms and total unresolved alarms.
5. Each alarm point shall be programmable to disallow the resolution of alarms until the alarm point has returned to its normal state.
6. Alarms shall transmit to the central station in real time except for allowing connection time for dial-up locations.
7. Alarms shall be displayed and managed from a minimum of four different windows.
 - a. Input Status Window: Overlay status icon with a large red blinking icon. Selecting the icon will acknowledge the alarm.
 - b. History Log Transaction Window: Display name, time, and date in red text. Selecting red text will acknowledge the alarm.
 - c. Alarm Log Transaction Window: Display name, time, and date in red. Selecting red text will acknowledge the alarm.
 - d. Graphic Map Display: Display a steady colored icon representing each alarm input location. Change icon to flashing red when the alarm occurs. Change icon from flashing red to steady red when the alarm is acknowledged.
8. Once an alarm is acknowledged, the operator shall be prompted to enter comments about the nature of the alarm and actions taken. Operator's comments may be manually entered or selected from a programmed predefined list, or a combination of both.
9. For locations where there are regular alarm occurrences, provide programmed comments. Selecting that comment shall clear the alarm.
10. The time and name of the operator who acknowledged and resolved the alarm shall be recorded in the database.
11. Identical alarms from the same alarm point shall be acknowledged at the same time the operator acknowledges the first alarm. Identical alarms shall be resolved when the first alarm is resolved.
12. Alarm functions shall have priority over downloading, retrieving, and updating database from workstations and controllers.

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13. When a reader-controlled output (relay) is opened, the corresponding alarm point shall be automatically bypassed.
- P. Monitor Display: Display text and graphic maps that include zone status integrated into the display. Colors are used for the various components and current data. Colors shall be uniform throughout the system.
1. Color Code:
 - a. FLASHING RED: Alerts operator that a zone has gone into an alarm or that primary power has failed.
 - b. STEADY RED: Alerts operator that a zone is in alarm and alarm has been acknowledged.
 - c. YELLOW: Advises operator that a zone is in access.
 - d. GREEN: Indicates that a zone is secure and that power is on.
 2. Graphics:
 - a. Support 32,000 graphic display maps and allow import of maps from a minimum of 16 standard formats from another drawing or graphics program.
 - b. Allow I/O to be placed on graphic maps by the drag-and-drop method.
 - c. Operators shall be able to view the inputs, outputs, and the point's name by moving the mouse cursor over the point on the graphic map.
 - d. Inputs or outputs may be placed on multiple graphic maps. The operator shall be able to toggle to view graphic maps associated with I/Os.
 - e. Each graphic map shall have a display-order sequence number associated with it to provide a predetermined order when toggled to different views.
 - f. Camera icons shall have the ability to be placed on graphic maps that, when selected by an operator, will open a video window, display the camera associated with that icon, and provide pan-tilt-zoom control.
 - g. Input, output, or camera placed on a map shall allow the ability to arm or bypass an input, open or secure an output, or control the pan-tilt-zoom function of the selected camera.
- Q. System test software enables operators to initiate a test of the entire system or of a particular portion of the system.
1. Test Report: The results of each test shall be stored for future display or printout. The report shall document the operational status of system components.
- R. Report-Generator Software: Include commands to generate reports for displaying, printing, and storing on disk and tape. Reports shall be stored by type, date, and time. Report printing shall be the lowest-priority activity. Report-generation mode shall be operator selectable but set up initially as periodic, automatic, or on request. Include time and date printed and the name of operator generating the report. Report formats may be configured by operators.
1. Automatic Printing: Setup shall specify, modify, or inhibit the report to be generated; the time the initial report is to be generated; the time interval between reports; the end of the period; and the default printer.
 2. Printing on Request: An operator may request a printout of any report.

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3. Alarm Reports: Reporting shall be automatic as initially set up. Include alarms recorded by system over the selected time and information about the type of alarm (such as door alarm, intrusion alarm, tamper alarm, etc.) the type of sensor, the location, the time, and the action taken.
4. Access and Secure Reports: Document zones placed in access, the time placed in access, and the time placed in secure mode.
5. Custom Reports: Reports tailored to exact requirements of who, what, when, and where. As an option, custom report formats may be stored for future printing.
6. Automatic History Reports: Named, saved, and scheduled for automatic generation.
7. Cardholder Reports: Include data, or selected parts of the data, as well as the ability to be sorted by name, card number, imprinted number, or by any of the user-defined fields.
8. Cardholder by Reader Reports: Based on who has access to a specific reader or group of readers by selecting the readers from a list.
9. Cardholder by Access-Level Reports: Display everyone that has been assigned to the specified access level.
10. Who Is "In" (Muster) Report:
 - a. Emergency Muster Report: One-click operation on toolbar launches report.
 - b. Cardholder Report. Contain a count of persons who are "In" at a selected Location and a detailed listing of name, date, and time of last use, sorted by the last reader used or by the group assignment.
11. Panel Labels Reports: Printout of control-panel field documentation including the actual location of equipment, programming parameters, and wiring identification. Maintain system installation data within system database so that data are available on-site at all times.
12. History Reports: Custom reports that allow the operator to select any date, time, event type, device, output, input, operator, Location, name, or cardholder to be included or excluded from the report.
 - a. Initially store history on the hard disk of the host workstation.
 - b. Permit viewing of the history on workstations or print history to any system printer.
 - c. The report shall be definable by a range of dates and times with the ability to have a daily start and stop time over a given date range.
 - d. Each report shall depict the date, time, event type, event description, and device; or I/O name, cardholder group assignment, and cardholder name or code number.
 - e. Each line of a printed report shall be numbered to ensure that the integrity of the report has not been compromised.
 - f. Total number of lines of the report shall be given at the end of the report. If the report is run for a single event such as "Alarms," the total shall reflect how many alarms occurred during that period.
13. Reports shall have the following four options:
 - a. View on screen.

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- b. Print to system printer. Include automatic print spooling and "Print To" options if more than one printer is connected to the system.
 - c. "Save to File" with full path statement.
 - d. System shall have the ability to produce a report indicating status of system inputs and outputs or of inputs and outputs that are abnormal, out of time zone, manually overridden, not reporting, or in alarm.
 14. Custom Code List Subroutine: Allow the access codes of system to be sorted and printed according to the following criteria:
 - a. Active, inactive, or future activate or deactivate.
 - b. Code number, name, or imprinted card number.
 - c. Group, Location access levels.
 - d. Start and stop code range.
 - e. Codes that have not been used since a selectable number of days.
 - f. In, out, or either status.
 - g. Codes with trace designation.
 15. The reports of system database shall allow options so that every data field may be printed.
 16. The reports of system database shall be constructed so that the actual position of the printed data shall closely match the position of the data on the data-entry windows.
- S. Anti-Passback:
1. System shall have global and local anti-passback features, selectable by Location. System shall support hard and soft anti-passback.
 2. Hard Anti-Passback: Once a credential holder is granted access through a reader with one type of designation (IN or OUT), the credential holder may not pass through that type of reader designation until the credential holder passes through a reader of opposite designation.
 3. Soft Anti-Passback: Should a violation of the proper IN or OUT sequence occur, access shall be granted, but a unique alarm shall be transmitted to the control station, reporting the credential holder and the door involved in the violation. A separate report may be run on this event.
 4. Timed Anti-Passback: A controller capability that prevents an access code from being used twice at the same device (door) within a user-defined amount of time.
 5. Provide four separate zones per Location that can operate without requiring interaction with the host workstation (done at controller). Each reader shall be assignable to one or all four anti-passback zones. In addition, each anti-passback reader can be further designated as "Hard," "Soft," or "Timed" in each of the four anti-passback zones. The four anti-passback zones shall operate independently.
 6. The anti-passback schemes shall be definable for each individual door.
 7. The Master Access Level shall override anti-passback.
 8. System shall have the ability to forgive (or reset) an individual credential holder or the entire credential-holder population anti-passback status to a neutral status.

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- T. Visitor Assignment:
1. Provide for and allow an operator to be restricted to only working with visitors. The visitor badging subsystem shall assign credentials and enroll visitors. Allow only those access levels that have been designated as approved for visitors.
 2. Provide an automated log of visitor name, time and doors accessed, and name of person contacted.
 3. Allow a visitor designation to be assigned to a credential holder.
 4. Security access system shall be able to restrict the access levels that may be assigned to credentials issued to visitors.
 5. Allow operator to recall visitors' credential-holder file once a visitor is enrolled in the system.
 6. The operator may designate any reader as one that deactivates the credential after use at that reader. The history log shall show the return of the credential.
 7. System shall have the ability to use the visitor designation in searches and reports. Reports shall be able to print all or any visitor activity.
- U. Training Software: Enables operators to practice system operation, including alarm acknowledgment, alarm assessment, response force deployment, and response force communications. System shall continue normal operation during training exercises and shall terminate exercises when an alarm signal is received at the console.
- V. Entry-Control Enrollment Software: Database management functions that allow operators to add, delete, and modify access data as needed.
1. The enrollment station shall not have alarm response or acknowledgment functions.
 2. Provide multiple, password-protected access levels. Database management and modification functions shall require a higher operator access level than personnel enrollment functions.
 3. The program shall provide means to disable the enrollment station when it is unattended, to prevent unauthorized use.
 4. The program shall provide a method to enter personnel identifying information into the entry-control database files through enrollment stations. In the case of personnel identity-verification subsystems, this shall include biometric data. Allow entry of personnel identifying information into the system database using menu selections and data fields. The data field names shall be customized during setup to suit user and site needs. Personnel identity-verification subsystems selected for use with the system shall fully support the enrollment function and shall be compatible with the entry-control database files.
 5. Cardholder Data: Provide 99 user-defined fields. System shall have the ability to run searches and reports using any combination of these fields. Each user-defined field shall be configurable, using any combination of the following features:
 - a. MASK: Determines a specific format with which data must comply.
 - b. REQUIRED: Operator is required to enter data into field before saving.
 - c. UNIQUE: Data entered must be unique.

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- d. DEACTIVATE DATE: Data entered will be evaluated as an additional deactivate date for all cards assigned to this cardholder.
- e. NAME ID: Data entered will be considered a unique ID for the cardholder.
- 6. Personnel Search Engine: A report generator with capabilities such as search by last name, first name, group, or any predetermined user-defined data field; by codes not used in definable number of days; by skills; or by seven other methods.
- 7. Multiple Deactivate Dates for Cards: User-defined fields to be configured as additional stop dates to deactivate any cards assigned to the cardholder.
- 8. Batch card printing.
- 9. Default card data can be programmed to speed data entry for sites where most card data are similar.
- 10. Enhanced ASCII File Import Utility: Allows the importing of cardholder data and images.
- 11. Card Expire Function: Allows readers to be configured to deactivate cards when a card is used at selected devices.

2.5 SYSTEM DATABASE

- A. Database and database management software shall define and modify each point in database using operator commands. Definition shall include parameters and constraints associated with each system device.
- B. Database Operations:
 - 1. System data management shall be in a hierarchical menu-tree format, with navigation through expandable menu branches and manipulated with use of menus and icons in a main menu and system toolbar.
 - 2. Navigational Aids:
 - a. Toolbar icons for add, delete, copy, print, capture image, activate, deactivate, and muster report.
 - b. Point and click feature to facilitate data manipulation.
 - c. Next and previous command buttons visible when editing database fields to facilitate navigation from one record to the next.
 - d. Copy command and copy tool in the toolbar to copy data from one record to create a new similar record.
 - 3. Data entry shall be automatically checked for duplicate and illegal data and shall be verified for valid format.
 - 4. System shall generate a memo or note field for each item that is stored in database, allowing the storing of information about any defining characteristics of the item. Memo field is used for noting the purpose for which the item was entered, reasons for changes that were made, and the like.
- C. File Management:

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1. File management shall include database backup and restoration system, allowing selection of storage media, including 3.5-inch floppy disk, Zip and Jaz drives, and designated network resources.
 2. Operations shall be both manual and automatic modes. The number of automatic sequential backups before the oldest backup will be overwritten; FIFO mode shall be operator selectable.
 3. Backup program shall provide manual operation from any workstation on the LAN and shall operate while system remains operational.
- D. Operator Passwords:
1. Support up to 32,000 individual system operators, each with a unique password.
 2. Refer to owner requirements for password configurations.
 3. Allow passwords to be case sensitive.
 4. Passwords shall not be displayed when entered.
 5. Passwords shall have unique and customizable password profile, and allow several operators to share a password profile. Include the following features in the password profile:
 - a. Predetermine the highest-level password profile for access to all functions and areas of program.
 - b. Allow or disallow operator access to any program operation, including the functions of View, Add, Edit, and Delete.
 - c. Restrict doors to which an operator can assign access.
 6. Operators shall use a user name and password to log on to system. This user name and password shall be used to access database areas and programs as determined by the associated profile.
 7. Make provision to allow the operator to log off without fully exiting program. User may be logged off but program will remain running while displaying the login window for the next operator.
- E. Access Card/Code Operation and Management: Access authorization shall be by card, by a manually entered code (PIN), or by a combination of both (card plus PIN).
1. Access authorization shall verify the facility code first, the card or card-and-PIN validation second, and the access level (time of day, day of week, date), anti-passback status, and number of uses last.
 2. Use data-entry windows to view, edit, and issue access levels. Access-authorization entry-management system shall maintain and coordinate all access levels to prevent duplication or the incorrect creation of levels.
 3. Allow assignment of multiple cards/codes to a cardholder.
 4. Allow assignment of up to four access levels for each Location to a cardholder. Each access level may contain any combination of doors.
 5. Each door may be assigned four time zones.
 6. Access codes may be up to 11 digits in length.

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7. Software shall allow the grouping of locations so cardholder data can be shared by all locations in the group.
 8. Visitor Access: Issue a visitor badge for data tracking or photo ID purposes without assigning that person a card or code.
 9. Cardholder Tracing: Allow for selection of cardholder for tracing. Make a special audible and visible annunciation at control station when a selected card or code is used at a designated code reader. Annunciation shall include an automatic display of the cardholder image.
 10. Allow each cardholder to be given either an unlimited number of uses or a number from one to 9999 that regulates the number of times the card can be used before it is automatically deactivated.
 11. Provide for cards and codes to be activated and deactivated manually or automatically by date. Provide for multiple deactivate dates to be preprogrammed.
- F. Security Access Integration:
1. Photo ID badging and photo verification shall use the same database as the security access and may query data from cardholder, group, and other personal information to build a custom ID badge.
 2. Automatic or manual image recall and manual access based on photo verification shall also be a means of access verification and entry.
 3. System shall allow sorting of cardholders together by group or other characteristic for a fast and efficient method of reporting on, and enabling or disabling, cards or codes.
- G. Operator Comments:
1. With the press of one appropriate button on the toolbar, the user shall be permitted to enter operator comments into the history at any time.
 2. Automatic prompting of operator comment shall occur before the resolution of each alarm.
 3. Operator comments shall be recorded by time, date, and operator number.
 4. Comments shall be sorted and viewed through reports and history.
 5. The operator may enter comments in two ways; either or both may be used:
 - a. Manually entered through keyboard data entry (typed), up to 65,000 characters per each alarm.
 - b. Predefined and stored in database for retrieval on request.
 6. System shall have a minimum of 999 predefined operator comments with up to 30 characters per comment.
- H. Group:
1. Group names may be used to sort cardholders into groups that allow the operator to determine the tenant, vendor, contractor, department, division, or any other designation of a group to which the person belongs.

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2. System software shall have the capacity to assign one of 32,000 group names to an access authorization.
3. Make provision in software to deactivate and reactivate all access authorizations assigned to a particular group.
4. Allow sorting of history reports and code list printouts by group name.

I. Time Zones:

1. Each zone consists of a start and stop time for seven days of the week and three holiday schedules. A time zone is assigned to inputs, outputs, or access levels to determine when an input shall automatically arm or disarm, when an output automatically opens or secures, or when access authorization assigned to an access level will be denied or granted.
2. Up to four time zones may be assigned to inputs and outputs to allow up to four arm or disarm periods per day or four lock or unlock periods per day; up to three holiday override schedules may be assigned to a time zone.
3. Data-entry window shall display a dynamically linked bar graph showing active and inactive times for each day and holiday, as start and stop times are entered or edited.
4. System shall have the capacity for **2048** time zones for each Location.

J. Holidays:

1. Three different holiday schedules may be assigned to a time zone. Holiday schedule consists of date in format MM/DD/YYYY and a description. When the holiday date matches the current date of the time zone, the holiday schedule replaces the time-zone schedule for that 24-hour period.
2. System shall have the capacity for 32,000 holidays.
3. Three separate holiday schedules may be applied to a time zone.
4. Holidays have an option to be designated as occurring on the designated date each year. These holidays remain in the system and will not be purged.
5. Holidays not designated to occur each year shall be automatically purged from the database after the date expires.

K. Access Levels:

1. System shall allow for the creation of up to 32,000 access levels.
2. One level shall be predefined as the Master Access Level. The Master Access Level shall work at all doors at all times and override any anti-passback.
3. System shall allow for access to be restricted to any area by reader and by time. Access levels shall determine when and where an Identifier is authorized.
4. System shall be able to create multiple door and time-zone combinations under the same access level so that an Identifier may be valid during different time periods at different readers even if the readers are on the same controller.

L. User-Defined Fields:

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1. System shall provide a minimum of 99 user-defined fields, each with up to 50 characters, for specific information about each credential holder.
2. System shall accommodate a title for each field; field length shall be 20 characters.
3. A "Required" option may be applied to each user-defined field that, when selected, forces the operator to enter data in the user-defined field before the credential can be saved.
4. A "Unique" option may be applied to each user-defined field that, when selected, will not allow duplicate data from different credential holders to be entered.
5. Data format option may be assigned to each user-defined field that will require the data to be entered with certain character types in specific spots in the field entry window.
6. A user-defined field, if selected, will define the field as a deactivate date. The selection shall automatically cause the data to be formatted with the windows MM/DD/YYYY date format. The credential of the holder will be deactivated on that date.
7. A search function shall allow any one user-defined field or combination of user-defined fields to be searched to find the appropriate cardholder. The search function shall include a search for a character string.
8. System shall have the ability to print cardholders based on and organized by the user-defined fields.

2.6 SURGE AND TAMPER PROTECTION

- A. Surge Protection: Protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads. Include surge protection for external wiring of each conductor-entry connection to components.
 1. Minimum Protection for Power Connections 120 V and More: Auxiliary panel suppressors complying with requirements in Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits."
 2. Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Connections: Comply with requirements in Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits" as recommended by manufacturer for type of line being protected.
- B. Tamper Protection: Tamper switches on enclosures, control units, pull boxes, junction boxes, cabinets, and other system components shall initiate a tamper-alarm signal when unit is opened or partially disassembled. Control-station control-unit alarm display shall identify tamper alarms and indicate locations.

2.7 CENTRAL-STATION HARDWARE

- A. Central-Station Computer: Standard workstation of modular design.
- B. Servers

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1. Description: x86 based computer used for client-server computing.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Avigilon ACM
3. Mounting: Rack
4. Power: dual power supply, minimum 300 W.
5. Performance Requirements:
 - a. Performance requirements may dictate equipment exceeding minimum requirements indicated.
 - b. Energy Star compliant.
6. Processor:
 - a. Minimum Speed: 3.8 Ghz
 - b. Cores: Quad
 - c. Series: Intel Xeon
7. RAM:
 - a. Capacity: 32 GB.
 - b. Speed and Type: 2x16 2400MT/s DDR4 UDIMMs
8. Redundant Array of Independent Disks: Four configuration.
9. Drive Bays: Eight at 2.5 inches or eight at 3.5 inches. Hot swappable.
10. Hard Drives: Solid state
11. Hard-Drive Storage: Four drives each with 480 TB storage.
12. Network Interface: Dual port Gigabit Ethernet
13. Next-day on-site warranty for three year period following Substantial Completion.
14. Servers shall include the following:
 - a. Full-feature backup server (server and backup minimum requirement).
 - b. Software licenses.
 - c. Cable installation between server(s) and network.
15. Web Server:
 - a. If required to be separate, include Web server hardware and software to match, except backup server is not required.
 - b. Firewalls between server Web and networks.
 - c. Password protection for access to server from Web server.
 - d. Cable installation between the server(s) and building Ethernet network.
16. Power each server through a UPS unit.

2.8 CONTROLLERS

- A. Controllers: Intelligent peripheral control unit, complying with UL 294, that stores time, date, valid codes, access levels, and similar data downloaded from the central station or workstation for controlling its operation.

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- B. Subject to compliance with requirements in this article, manufacturers may use multipurpose controllers.
- C. Battery Backup: Sealed, lead acid; sized to provide run time during a power outage of 90 minutes, complying with UL 924.
- D. Alarm Annunciation Controller:
 - 1. The controller shall automatically restore communication within 10 seconds after an interruption with the field device network, with dc line supervision on each of its alarm inputs.
 - a. Inputs: Monitor dry contacts for changes of state that reflect alarm conditions. Provides at least eight alarm inputs, which are suitable for wiring as normally open or normally closed contacts for alarm conditions.
 - b. Alarm-Line Supervision:
 - 1) Supervise the alarm lines by monitoring each circuit for changes or disturbances in the signal, and for conditions as described in UL 1076 for line security equipment by monitoring for abnormal open, grounded, or shorted conditions using dc change measurements. System shall initiate an alarm in response to an abnormal current, which is a dc change of 10 percent or more for longer than 500 ms.
 - 2) Transmit alarm-line-supervision alarm to the central station during the next interrogation cycle after the abnormal current condition.
 - c. Outputs: Managed by central-station software.
 - 2. Auxiliary Equipment Power: A GFI service outlet inside the controller enclosure.
- E. Entry-Control Controller:
 - 1. Function: Provide local entry-control functions including one- and two-way communications with access-control devices such as card readers, keypads, door strikes, magnetic latches, gate and door operators, and exit push buttons.
 - a. Operate as a stand-alone portal controller using the downloaded database during periods of communication loss between the controller and the field-device network.
 - b. Accept information generated by the entry-control devices; automatically process this information to determine valid identification of the individual present at the portal:
 - 1) On authentication of the credentials or information presented, check privileges of the identified individual, allowing only those actions granted as privileges.
 - 2) Privileges shall include, but are not limited to, time of day control, day of week control, group control, and visitor escort control.
 - c. Maintain a date-, time-, and Location-stamped record of each transaction. A transaction is defined as any successful or unsuccessful attempt to gain access through a controlled portal by the presentation of credentials or other identifying information.
 - 2. Inputs:

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- a. Data from entry-control devices; use this input to change modes between access and secure.
 - b. Database downloads and updates from the central station that include enrollment and privilege information.
3. Outputs:
- a. Indicate success or failure of attempts to use entry-control devices and make comparisons of presented information with stored identification information.
 - b. Grant or deny entry by sending control signals to portal-control devices and mask intrusion-alarm annunciation from sensors stimulated by authorized entries.
 - c. Maintain a date-, time-, and Location-stamped record of each transaction and transmit transaction records to the central station.
 - d. Door Prop Alarm: If a portal is held open for longer than 30 seconds alarm sounds.
4. With power supplies sufficient to power at voltage and frequency required for field devices and portal-control devices.
5. Data Line Problems: For periods of loss of communication with the central station, or when data transmission is degraded and generating continuous checksum errors, the controller shall continue to control entry by accepting identifying information, making authentication decisions, checking privileges, and controlling portal-control devices.
- a. Store up to 1000 transactions during periods of communication loss between the controller and access-control devices for subsequent upload to the central station on restoration of communication.
6. Controller Power: NFPA 70, Class II power-supply transformer, with 12- or 24-V ac secondary, backup battery and charger.
- a. Backup Battery: Premium, valve regulated, recombinant-sealed, lead-calcium battery; spill proof; with a full one-year warranty and a pro rata 9-year warranty. With single-stage, constant-voltage-current, limited battery charger, comply with battery manufacturer's written instructions for battery terminal voltage and charging current recommendations for maximum battery life.
 - b. Backup Battery: Valve-regulated, recombinant-sealed, lead-acid battery; spill proof. With single-stage, constant-voltage-current, limited battery charger, comply with battery manufacturer's written instructions for battery terminal voltage and charging current recommendations for maximum battery life.
 - c. Backup Power-Supply Capacity: Five minutes of battery supply. Submit battery and charger calculations.
 - d. Power Monitoring: Provide manual, dynamic battery-load test, initiated and monitored at the control center; with automatic disconnection of the controller when battery voltage drops below controller limits. Report by using local controller-mounted digital displays and by communicating status to central station. Indicate normal power on and battery charger on trickle charge. Indicate and report the following:
 - 1) Trouble Alarm: Normal power-off load assumed by battery.

- 2) Trouble Alarm: Low battery.
- 3) Alarm: Power off.

2.9 DOOR AND GATE HARDWARE INTERFACE

- A. Exit Device with Alarm: Operation of the exit device shall generate an alarm and annunciate a local alarm. Exit device and alarm contacts are specified in Section 087100 "Door Hardware."
- B. Exit Alarm: Operation of a monitored door shall generate an alarm. Exit devices and alarm contacts are specified in Section 087100 "Door Hardware."
- C. Electric Door Strikes: Use end-of-line resistors to provide power-line supervision. Signal switches shall transmit data to controller to indicate when the bolt is not engaged and the strike mechanism is unlocked, and they shall report a forced entry. Power and signal shall be from the controller. Electric strikes are specified in Section 087100 "Door Hardware."
- D. Electromagnetic Locks: End-of-line resistors shall provide power-line supervision. Lock status sensing signal shall positively indicate door is secure. Power and signal shall be from the controller. Electromagnetic locks are specified in Section 087100 "Door Hardware."

2.10 FIELD-PROCESSING SOFTWARE

- A. Operating System:
 1. Local processors shall contain an operating system that controls and schedules that local processor's activities in real time.
 2. Local processor shall maintain a point database in its memory that includes parameters, constraints, and the latest value or status of all points connected to that local processor.
 3. Execution of local processor application programs shall utilize the data in memory resident files.
 4. Operating system shall include a real-time clock function that maintains the seconds, minutes, hours, date, and month, including day of the week.
 5. Local processor real-time clock shall be automatically synchronized with the central station at least once per day to plus or minus 10 seconds (the time synchronization shall be accomplished automatically, without operator action and without requiring system shutdown).
- B. Startup Software:
 1. Causes automatic commencement of operation without human intervention, including startup of all connected I/O functions.
 2. Local processor restart program based on detection of power failure at the local processor shall be included in the local processor software.
 3. Initiates operation of self-test diagnostic routines.

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4. Upon failure of the local processor, if the database and application software are no longer resident, the local processor shall not restart and systems shall remain in the failure mode indicated until the necessary repairs are made.
 5. If the database and application programs are resident, the local processor shall immediately resume operation.
- C. Operating Mode:
1. Local processors shall control and monitor inputs and outputs as specified, independent of communications with the central station or designated workstations.
 2. Alarms, status changes, and other data shall be transmitted to the central station or designated workstations when communications circuits are operable.
 3. If communications are not available, each local processor shall function in a stand-alone mode and operational data, including the status and alarm data normally transmitted to the central station or designated workstations, shall be stored for later transmission to the central station or designated workstations.
 4. Storage for the latest 4000 events shall be provided at local processors, as a minimum.
 5. Local processors shall accept software downloaded from the central station.
 6. Panel shall support flash ROM technology to accomplish firmware downloads from a central location.
- D. Failure Mode: Upon failure for any reason, each local processor shall perform an orderly shutdown and force all local processor outputs to a predetermined (failure-mode) state, consistent with the failure modes shown and the associated control device.
- E. Functions:
1. Monitoring of inputs.
 2. Control of outputs.
 3. Reporting of alarms automatically to the central station.
 4. Reporting of sensor and output status to central station upon request.
 5. Maintenance of real time, automatically updated by the central station at least once a day.
 6. Communication with the central station.
 7. Execution of local processor resident programs.
 8. Diagnostics.
 9. Download and upload data to and from the central station.

2.11 FIELD-PROCESSING HARDWARE

A. Alarm Annunciation Local Processor:

1. Respond to interrogations from the field device network, recognize and store alarm status inputs until they are transmitted to the central station, and change outputs based on commands received from the central station.
2. Local processor shall also automatically restore communication within 10 seconds after an interruption with the field device network and provide dc line supervision on each of its alarm inputs.
3. Local processor inputs shall monitor dry contacts for changes of state that reflect alarm conditions.
4. Local processor shall have at least eight alarm inputs which allow wiring contacts as normally open or normally closed for alarm conditions; and shall provide line supervision for each input by monitoring each input for abnormal open, grounded, or shorted conditions using dc current change measurements.
5. Local processor shall report line supervision alarms to the central station.
6. Alarms shall be reported for any condition that remains abnormal at an input for longer than 500 milliseconds.
7. Alarm condition shall be transmitted to the central computer during the next interrogation cycle.
8. Local processor outputs shall reflect the state of commands issued by the central station.
9. Outputs shall be a form C contact and shall include normally open and normally closed contacts.
10. Local processor shall have at least four command outputs.
11. Local processor shall be able to communicate with the central station via RS-485 or TCP/IP as a minimum.

B. Processor Power Supply:

1. Local processor and sensors shall be powered from an uninterruptible power source.
2. Uninterruptible power source shall provide eight hours of battery back-up power in the event of primary power failure and shall automatically fully recharge the batteries within 12 hours after primary power is restored.
3. If the facility is without an emergency generator, the uninterruptible power source shall provide 24 hours of battery backup power.
4. There shall be no equipment malfunctions or perturbations or loss of data during the switch from primary to battery power and vice versa.
5. Batteries shall be sealed, non-outgassing type.
6. Power supply shall be equipped with an indicator for ac input power and an indicator for dc output power.

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7. Loss of primary power shall be reported to the central station as an alarm.
- C. Auxiliary Equipment Power: A GFI service outlet shall be furnished inside the local processor's enclosure.
- D. Entry-Control Local Processor:
1. Entry-control local processor shall respond to interrogations from the field device network, recognize and store alarm status inputs until they are transmitted to the central station, and change outputs based on commands received from the central station.
 2. Local processor shall also automatically restore communication within 10 seconds after an interruption with the field device network and provide dc line supervision on each of its alarm inputs.
 3. Entry-control local processor shall provide local entry-control functions including communicating with field devices such as card readers, keypads, door strikes, magnetic latches, gate and door operators, and exit push buttons.
 4. Processor shall also accept data from entry-control field devices as well as database downloads and updates from the central station that include enrollment and privilege information.
 5. Processor shall send indications of successful or failed attempts to use entry-control field devices and shall make comparisons of presented information with stored identification information.
 6. Processor shall grant or deny entry by sending control signals to portal-control devices and mask intrusion-alarm annunciation from sensors stimulated by authorized entries.
 7. Entry-control local processor shall use inputs from entry-control devices to change modes between access and secure.
 8. Local processor shall maintain a date-time- and location-stamped record of each transaction and transmit transaction records to the central station.
 9. Processor shall operate as a stand-alone portal controller using the downloaded database during periods of communication loss between the local processor and the central station.
 10. Processor shall store a minimum of 4000 transactions during periods of communication loss between the local processor and the central station for subsequent upload to the central station upon restoration of communication.
 11. Local processor inputs shall monitor dry contacts for changes of state that reflect alarm conditions.
 12. Local processor shall have at least eight alarm inputs which allow wiring contacts as normally open or normally closed for alarm conditions; and shall also provide line supervision for each input by monitoring each input for abnormal open, grounded, or shorted conditions using dc current change measurements.
 13. Local processor shall report line supervision alarms to the central station.
 14. Alarms shall be reported for any condition that remains abnormal at an input for longer than 500 ms.

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15. Alarm condition shall be transmitted to the central station during the next interrogation cycle.
16. Entry-control local processor shall include the necessary software drivers to communicate with entry-control field devices. Information generated by the entry-control field devices shall be accepted by the local processor and automatically processed to determine valid identification of the individual present at the portal.
17. Upon authentication of the credentials or information presented, the local processor shall automatically check privileges of the identified individual, allowing only those actions granted as privileges.
18. Privileges shall include, but are not limited to, time of day control, day of week control, group control, and visitor escort control. The local processor shall maintain a date-time- and location-stamped record of each transaction.
19. Transaction is defined as any successful or unsuccessful attempt to gain access through a controlled portal by the presentation of credentials or other identifying information.
20. Local processor outputs shall reflect the state of commands issued by the central station.
21. Outputs shall be a form C contact and shall include normally open and normally closed contacts.
22. Local processor shall have at least four addressable outputs.
23. The entry-control local processor shall also provide control outputs to portal-control devices.
24. Local processor shall be able to communicate with the central station via RS-485 or TCP/IP as a minimum.
25. The system manufacturer shall provide strategies for downloading database information for panel configurations and cardholder data to minimize the required download time when using IP connectivity.

2.12 TRANSFORMERS

- A. NFPA 70, Class II control transformers, NRTL listed. Transformers for security access-control system shall not be shared with any other system.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine pathway elements intended for cables. Check raceways, cable trays, and other elements for compliance with space allocations, installation tolerances, hazards to cable installation, and other conditions affecting installation.
- B. Examine roughing-in for LAN and control cable conduit systems to workstations, controllers, card readers, and other cable-connected devices to verify actual locations of conduit and back boxes before device installation.

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

3.2 PREPARATION

- A. Comply with recommendations in SIA CP-01.
- B. Comply with TIA 606-B, "Administration Standard for Commercial Telecommunications Infrastructure."
- C. Product Schedules: Obtain detailed product schedules from manufacturer of access-control system or develop product schedules to suit Project. Fill in all data available from Project plans and specifications and publish as Product Schedules for review and approval.
 - 1. Record setup data for control station and workstations.
 - 2. For each Location, record setup of controller features and access requirements.
 - 3. Propose start and stop times for time zones and holidays, and match up access levels for doors.
 - 4. Assign action message names and compose messages.
 - 5. Set up alarms. Establish interlocks between alarms, intruder detection, and video surveillance features.
 - 6. Prepare and install alarm graphic maps.
 - 7. Develop user-defined fields.
 - 8. Develop screen layout formats.
 - 9. Discuss badge layout options; design badges.
 - 10. Complete system diagnostics and operation verification.
 - 11. Prepare a specific plan for system testing, startup, and demonstration.
 - 12. Develop acceptance test concept and, on approval, develop specifics of the test.
 - 13. Develop cable and asset-management system details; input data from construction documents. Include system schematics and Visio Technical Drawings in electronic format
- D. In meetings with Architect and Owner, present Product Schedules and review, adjust, and prepare final setup documents. Use approved, final Product Schedules to set up system software.

3.3 IDENTIFICATION

- A. In addition to requirements in this article, comply with applicable requirements in Section 270553 "Identification for Communications Systems" and with TIA 606-B.
- B. Using software specified in "Cable and Asset Management Software" Article, develop cable administration drawings for system identification, testing, and management. Use unique, alphanumeric designation for each cable, and label cable and jacks, connectors, and

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terminals to which it connects with the same designation. Use logical and systematic designations for facility's architectural arrangement.

- C. Label each terminal strip and screw terminal in each cabinet, rack, or panel.
 - 1. All wiring conductors connected to terminal strips shall be individually numbered, and each cable or wiring group being extended from a panel or cabinet to a building-mounted device shall be identified with the name and number of the particular device as shown.
 - 2. Each wire connected to building-mounted devices is not required to be numbered at the device if the color of the wire is consistent with the associated wire connected and numbered within the panel or cabinet.
- D. At completion, cable and asset management software shall reflect as-built conditions.

3.4 SYSTEM SOFTWARE AND HARDWARE

- A. Develop, install, and test software and hardware, and perform database tests for the complete and proper operation of systems involved. Assign software license to Owner.

3.5 STARTUP SERVICE

- A. Engage a factory-authorized service representative to supervise and assist with startup service.
 - 1. Complete installation and startup checks according to approved procedures that were developed in "Preparation" Article and with manufacturer's written instructions.
 - 2. Enroll and prepare badges and access cards for Owner's operators, management, and security personnel.
 - a. Provide qty. of One Hundred (100) cards to project.

3.6 PROTECTION

- A. Maintain strict security during the installation of equipment and software. Rooms housing the control station, and workstations that have been powered up shall be locked and secured with an activated burglar alarm and access-control system reporting to a central station complying with UL 1610, "Central-Station Burglar-Alarm Units," during periods when a qualified operator in the employ of Contractor is not present.

3.7 DEMONSTRATION

- A. **Train** Owner's maintenance personnel to adjust, operate, and maintain security access system. See Section 017900 "Demonstration and Training."
- B. Develop separate training modules for the following:

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1. Computer system administration personnel to manage and repair the LAN and databases and to update and maintain software.
2. Operators who prepare and input credentials to man the control station and workstations and to enroll personnel.
3. Security personnel.
4. Hardware maintenance personnel.
5. Corporate management.

END OF SECTION

SECTION 28 1600 - INTRUSION DETECTION

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes intrusion detection with communication links to perform monitoring, alarm, and control functions. Contractor is responsible for providing and installing a complete “turn-key” Intrusion system that meets or exceeds the specifications listed below and integrates with Access Control and Video Surveillance Systems.
- B. Related Sections:
 - 1. Section 28 23 00 "Video Surveillance" for CCTV cameras that are used as devices for video motion detection.
 - 2. Section 28 13 00 “Access Control System” for Access to building utilizing owner designated card reader locations to arm or disarm system.

1.2 DEFINITIONS

- A. Control Unit: System component that monitors inputs and controls outputs through various circuits.
- B. Master Control Unit: System component that accepts inputs from other control units and may also perform control-unit functions. The unit has limited capacity for the number of protected zones and is installed at an unattended location or at a location where it is not the attendant's primary function to monitor the security system.
- C. Monitoring Station: Facility that receives signals and has personnel in attendance at all times to respond to signals. A central station is a monitoring station that is listed.
- D. Standard Intruder: A person who weighs 100 lb (45 kg) or less and whose height is 60 inches (1525 mm) or less; dressed in a long-sleeved shirt, slacks, and shoes unless environmental conditions at the site require protective clothing.
- E. Standard-Intruder Movement: Any movement, such as walking, running, crawling, rolling, or jumping, of a "standard intruder" in a protected zone.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: Detail assemblies of standard components that are custom assembled for specific application on this Project.

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1. Raceway Riser Diagrams: Detail raceway runs required for intrusion detection. Include designation of devices connected by raceway, raceway type and size, and type and size of wire and cable fill for each raceway run.
 2. UPS: Sizing calculations.
 3. Site and Floor Plans: Indicate final outlet and device locations, routing of raceways, and cables inside and outside the building. Include room layout for master control-unit console, terminal cabinet, racks, and UPS.
 4. Master Control-Unit Console Layout: Show required artwork and device identification.
 5. Device Address List: Coordinate with final system programming.
 6. System Wiring Diagrams: Include system diagrams unique to Project. Show connections for all devices, components, and auxiliary equipment. Include diagrams for equipment and for system with all terminals and interconnections identified.
 7. Details of surge-protection devices and their installation.
 8. Sensor detection patterns and adjustment ranges.
- C. Equipment and System Operation Description: Include method of operation and supervision of each component and each type of circuit. Show sequence of operations for manually and automatically initiated system or equipment inputs. Description must cover this specific Project; manufacturer's standard descriptions for generic systems are unacceptable.
- D. Samples: For units with factory-applied color finishes.

1.4 QUALIFICATIONS

- A. Communications Cabling: The Contractor shall have (5) five years of documented experience performing cable placement, splicing, termination, connecting, and testing for each of the media types and (3) three years of applicable experience with the proposed system manufacturer. In the case of newer technologies that do not have a (3) three year history, the Contractor shall have documented experience for at least half of the lifetime of the new technology. The approved contractor shall, at a minimum, maintain a ratio of one manufacturer or BICSI certified installer for every two non-certified installers assigned to the project.
- B. The contractor shall have on staff a BICSI Certified RCDD as a permanent employee. This staff member shall have been on staff for a minimum of (1) one year prior to the date of this projects release for bid.
- C. The contractor shall have on staff at least (1) one BICSI Certified Technician and this staff member shall have been a full time employee for no less than (1) one year prior to the date of this projects release for bid. A BICSI Certified Technician shall be employed as the on-site Field Supervisor for this project.
- D. The contractor shall provide resumes for the Project Manager, Supervisors and any skilled technicians or installers. Each resume shall include applicable certification documents provided by the manufacturer or BICSI.
 1. Project Manager, Supervisors, and Principal Skilled Technicians: minimum of (5) five years' experience in like work.

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2. Category 6 Unshielded Twisted Pair and Fiber Optic Cable Technicians: documented training, licensing, and/or certification for the types of media specified, as applicable as well as certification from the manufacturer of the solution chosen by the owner.

1.5 PROGRAMMING

- A. The contractor shall engage the Design Team, Owner and Architect to schedule a pre-submittal meeting to review programming and unique project requirements to ensure system components and configurations are in line with owner requirements.

1.6 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer, qualified layout technician, installation supervisor, field inspector and company. The contractor shall provide resumes for the Project Manager, Supervisors and any skilled technicians or installers. Each resume shall include applicable certification documents provided by the manufacturer or BICSI.
 1. Project Manager, installation supervisor, and Principal Skilled Technicians: As a minimum be required to have no less than (5) five years' experience in like work.
 2. The Company/Contractor proposing shall provide historical data confirming the company has a minimum of (5) five years applicable experience.
 3. The Company/Contractor shall have a minimum of (3) three projects of similar size and type within the last (2) years. References for all submitted projects are required to assist with the evaluation.
- B. Category 6 Unshielded Twisted Pair and Fiber Optic Cable Technicians: Documented training, licensing, and/or certification for the types of media specified, as applicable as well as certification from the manufacturer of the solution chosen by the owner.
- C. Source quality-control reports.
- D. Field quality-control reports.
- E. Warranty: Sample of special warranty

1.7 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.8 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Intrusion Detection Devices: Furnish quantity equal to five percent of the number of units of each type installed, but no less than one of each type.
 2. Fuses: Three of each kind and size.

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3. Tool Kit: Provide six sets of tools for use with security fasteners, each packaged in a compartmented kit configured for easy handling and storage.
4. Security Fasteners: Furnish no less than 1 box for every 50 boxes or fraction thereof, of each type and size of security fastener installed.

1.9 QUALITY ASSURANCE

- A. Installer Qualifications:
 1. An employer of workers, at least one of whom is a technician certified by the National Burglar & Fire Alarm Association.
 2. Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
- B. Testing Agency Qualifications: Member Company of NETA or an NRTL.
- 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. Control Units, Devices, and Communications with Monitoring Station: Listed and labeled by a qualified testing agency for compliance with SIA CP-01.
- E. FM Global Compliance: FM-Approved and -labeled intrusion detection devices and equipment.
- F. Comply with NFPA 70.

1.10 PROJECT CONDITIONS

- A. Environmental Conditions: Capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:
 1. Altitude: Sea level to 4000 feet (1220 m).
 2. Master Control Unit: Rated for continuous operation in an ambient of 60 to 85 deg. F (16 to 29 deg. C) and a relative humidity of 20 to 80 percent, noncondensing.
 3. Interior, Controlled Environment: System components, except master control unit, installed in temperature-controlled interior environments shall be rated for continuous operation in ambient of 36 to 122 deg. F (2 to 50 deg. C) dry bulb and 20 to 90 percent relative humidity, noncondensing.
 4. Interior, Uncontrolled Environment: System components installed in non-temperature-controlled interior environments shall be rated for continuous operation in ambient of 0 to 122 deg. F (minus 18 to plus 50 deg. C) dry bulb and 20 to 90 percent relative humidity, noncondensing.
 5. Exterior Environment: System components installed in locations exposed to weather shall be rated for continuous operation in ambient of minus 30 to plus 122 deg. F (minus

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34 to plus 50 deg. C) dry bulb and 20 to 90 percent relative humidity, condensing. Comply with UL 294 and UL 639 for outdoor-use equipment. Rate for continuous operation when exposed to rain as specified in NEMA 250, winds up to 85 mph (137 km/h) and snow cover up to 24 inches (610 mm) thick.

6. Hazardous Environment: System components located in areas where fire or explosion hazards may exist because of flammable gases or vapors, flammable liquids, combustible dust, or ignitable fibers or flying's shall be rated, listed, and installed according to NFPA 70.

1.11 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer and Installer agree to repair or replace components of intrusion detection devices and equipment that fails in materials or workmanship within specified warranty period.
 1. Warranty Period: Two years from date of Substantial Completion.

PART 2 PRODUCTS

2.1 FUNCTIONAL DESCRIPTION OF SYSTEM

- A. Description: Hard-wired, Multiplexed, modular, microprocessor-based controls, intrusion sensors and detection devices, and communication links to perform monitoring, alarm, and control functions and integrate with Video Surveillance and Access Control Systems.
- B. Supervision: System components shall be continuously monitored for normal, alarm, supervisory, and trouble conditions. Indicate deviations from normal conditions at any location in system. Indication includes identification of device or circuit in which deviation has occurred and whether deviation is an alarm or malfunction.
 1. Alarm Signal: Display at master control unit and actuate audible and visual alarm devices.
 2. Trouble Condition Signal: Distinct from other signals, indicating that system is not fully functional. Trouble signal shall indicate system problems such as battery failure, open or shorted transmission line conductors, or control-unit failure.
 3. Supervisory Condition Signal: Distinct from other signals, indicating an abnormal condition as specified for the particular device or control unit.
- C. System Control: Master control unit shall directly monitor intrusion detection units and connecting wiring.
- D. System shall automatically reboot program without error or loss of status or alarm data after any system disturbance.
- E. Operator Commands:

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1. Help with System Operation: Display all commands available to operator. Help command, followed by a specific command, shall produce a short explanation of the purpose, use, and system reaction to that command.
 2. Acknowledge Alarm: To indicate that alarm message has been observed by operator.
 3. Place Protected Zone in Access: Disable all intrusion-alarm circuits of a specific protected zone. Tamper circuits may not be disabled by operator.
 4. Place Protected Zone in Secure: Activate all intrusion-alarm circuits of a protected zone.
 5. Protected Zone Test: Initiate operational test of a specific protected zone.
 6. System Test: Initiate system-wide operational test.
 7. Print reports.
- F. Timed Control at Master Control Unit: Allow automatically timed "secure" and "access" functions of selected protected zones.
- G. Automatic Control of Related Systems: Alarm or supervisory signals from certain intrusion detection devices control the following functions in related systems:
1. Switch selected lights.
 2. Shift elevator control to a different mode.
 3. Open a signal path between certain intercommunication stations.
 4. Shift sound system to "listening mode" and open a signal path to certain system speakers.
 5. Place's calls to the safety director and principles once an event has transpired.
- H. Printed Record of Events: Print a record of alarm, supervisory, and trouble events on system printer. Sort and report by protected zone, device, and function. When master control unit receives a signal, print a report of alarm, supervisory, or trouble condition. Report type of signal (alarm, supervisory, or trouble), protected zone description, date, and time of occurrence. Differentiate alarm signals from other indications. When system is reset, report reset event with the same information concerning device, location, date, and time. Commands shall initiate the reporting of a list of current alarm, supervisory, and trouble conditions in system or a log of past events.
- I. Response Time: Two seconds between actuation of any alarm and its indication at master control unit.
- J. Circuit Supervision: Supervise all signal and data transmission lines, links with other systems, and sensors from master control unit. Indicate circuit and detection device faults with both protected zone and trouble signals, sound a distinctive audible tone, and illuminate an LED. Maximum permissible elapsed time between occurrence of a trouble condition and indication at master control unit is 20 seconds. Initiate an alarm in response to opening, closing, shorting, or grounding of a signal or data transmission line.
- K. Programmed Secure-Access Control: System shall be programmable to automatically change status of various combinations of protected zones between secure and access conditions at scheduled times. Status changes may be preset for repetitive, daily, and weekly; specially scheduled operations may be preset up to a year in advance. Manual secure-access control stations shall override programmed settings.

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- L. Manual Secure-Access Control: Coded entries at manual stations shall change status of associated protected zone between secure and access conditions.

2.2 SYSTEM COMPONENT REQUIREMENTS

- A. Surge Protection: Protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads. Include surge protection for external wiring of each conductor entry connection to components.
 - 1. Minimum Protection for Power Lines 120 V and More: Auxiliary panel suppressors complying with requirements in Section 26 43 13 "Surge Protection for Low-Voltage Electrical Power Circuits."
 - 2. Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Lines: Listed and labeled by a qualified testing agency for compliance with NFPA 731.
- B. Intrusion Detection Units: Listed and labeled by a qualified testing agency for compliance with UL 639.
- C. Interference Protection: Components shall be unaffected by radiated RFI and electrical induction of 15 V/m over a frequency range of 10 to 10,000 MHz and conducted interference signals up to 0.25-V rms injected into power supply lines at 10 to 10,000 MHz.
- D. Tamper Protection: Tamper switches on detection devices, control units, annunciators, pull boxes, junction boxes, cabinets, and other system components shall initiate a tamper-alarm signal when unit is opened or partially disassembled and when entering conductors are cut or disconnected. Master control-unit alarm display shall identify tamper alarms and indicate locations.
- E. Self-Testing Devices: Automatically test themselves periodically, but not less than once per hour, to verify normal device functioning and alarm initiation capability. Devices transmit test failure to master control unit.
- F. Antimasking Devices: Automatically check operation continuously or at intervals of a minute or less, and use signal-processing logic to detect blocking, masking, jamming, tampering, or other operational dysfunction. Devices transmit detection of operational dysfunction to master control unit as an alarm signal.
- G. Addressable Devices: Transmitter and receivers shall communicate unique device identification and status reports to master control unit.
- H. Remote-Controlled Devices: Individually and remotely adjustable for sensitivity and individually monitored at master control unit for calibration, sensitivity, and alarm condition.

2.3 ENCLOSURES

- A. Interior Sensors: Enclosures that protect against dust, falling dirt, and dripping noncorrosive liquids.
- B. Interior Electronics: NEMA 250, Type 12.

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- C. Exterior Electronics: NEMA 250, Type 4X, fiberglass, stainless steel.
- D. Corrosion Resistant: NEMA 250, Type 4X, PVC, stainless steel.
- E. Screw Covers: Where enclosures are readily accessible, secure with security fasteners of type appropriate for enclosure.

2.4 SECURE AND ACCESS DEVICES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work include, and are limited to, the following:
 - 1. Bosch Security Systems, Inc.
 - 2. DSC
 - 3. DMP
 - 4. Owner and Consultant approved equal.
- B. Keypad and Display Module: Arranged for entering and executing commands for system-status changes and for displaying system-status and command-related data.
- C. Key-Operated Switch: Change protected zone between secure and access conditions.

2.5 DOOR AND WINDOW SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work include, and are limited to, the following:
 - 1. Contractor Preference – devices to be fully compatible with chosen system manufacturer.
- B. Description: Balanced-magnetic switch, complying with UL 634, installed on frame with integral overcurrent device to limit current to 80 percent of switch capacity. Bias magnet and minimum of two encapsulated reed switches shall resist compromise from introduction of foreign magnetic fields.
- C. Flush-Mounted Switches: Unobtrusive and flush with surface of door and window frame.
- D. Overhead Door Switch: Balanced-magnetic type, listed for outdoor locations, and having door-mounted magnet and floor-mounted switch unit.

2.6 PIR SENSORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work include, and are limited to, the following:
 - 1. Contractor Preference – devices to be fully compatible with chosen system manufacturer.

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- B. Listed and labeled by a qualified testing agency for compliance with SIA PIR-01.
- C. Description: Sensors detect intrusion by monitoring infrared wavelengths emitted from a human body within their protected zone and by being insensitive to general thermal variations.
 - 1. Wall-Mounted Unit Maximum Detection Range: 125 percent of indicated distance for individual units and not less than 50 feet (15 m). Provide adjustable coverage pattern as indicated.
 - 2. Ceiling-Mounted Unit Spot-Detection Pattern: Full 360-degree conical.
 - 3. Ceiling-Mounted Unit Pattern Size: 84-inch (2135-mm) diameter at floor level for units mounted 96 inches (2440 mm) above floor; 18-foot (5.5-m) diameter at floor level for units mounted 25 feet (7.6 m) above floor.
- D. Device Performance:
 - 1. Sensitivity: Adjustable pattern coverage to detect a change in temperature of 2 deg. F (1 deg. C) or less, and standard-intruder movement within sensor's detection patterns at any speed between 0.3 to 7.5 fps (0.09 to 2.3 m/s) across two adjacent segments of detector's field of view.
 - 2. Test Indicator: LED test indicator that is not visible during normal operation. When visible, indicator shall light when sensor detects an intruder. Locate test enabling switch under sensor housing cover.

2.7 MICROWAVE INTRUSION DETECTORS (INTERIOR)

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work include, and are limited to, the following:
 - 1. Contractor Preference – devices to be fully compatible with chosen system manufacturer.
- B. Device Performance: Microwave transmitter establishes an electromagnetic field in an adjustable detection pattern and detects intrusion by monitoring changes in that pattern.
 - 1. Sensitivity: Adjustable, able to detect standard-intruder movement within sensor's detection pattern at any speed between 0.3 to 7.5 fps (0.09 to 2.3 m/s). Sensor sensitivity adjustments shall be accessible only when sensor housing is removed, and sensors shall comply with 47 CFR 15.
 - 2. Activation Indicator: LED indicator shall not be visible during normal operation. Indicator shall light when sensor detects a standard intruder. Locate test-enabling switch under sensor housing cover.

2.8 ACOUSTIC-TYPE, GLASS-BREAK SENSORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work include, and are limited to, the following:

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1. Contractor Preference – devices to be fully compatible with chosen system manufacturer.
- B. Listed and labeled by a qualified testing agency for compliance with SIA GB-01.
- C. Device Performance: Detect unique, airborne acoustic energy spectrum caused by breaking glass.
 1. Sensor Element: Microprocessor-based, digital device to detect breakage of plate, laminate, tempered, and wired glass while rejecting common causes of false alarms. Detection pattern shall be at least a 20-foot (6-m) range.
 2. Hookup Cable: Factory installed, not less than 72 inches (1830 mm).
 3. Activation Indicator: LED on sensor housing that light when responding to vibrations, remaining on until manually reset at sensor control unit or at master control unit.
 4. Control Unit: Integral with sensor housing or in a separate assembly, locally adjustable by control under housing cover.
 5. Glass-Break Simulator: A device to induce frequencies into protected glass pane that simulate breaking glass without causing damage to glass.

2.9 PIEZOELECTRIC-TYPE, GLASS-BREAK SENSORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work include, and are limited to, the following:
 1. Contractor Preference – devices to be fully compatible with chosen system manufacturer.
- B. Listed and labeled by a qualified testing agency for compliance with SIA GB-01.
- C. Device Performance: Detect unique, high-frequency vibrations caused by breaking glass.
 1. Sensor Element: Piezoelectric crystals in a housing designed to mount directly to a glass surface with adhesive provided by element manufacturer. Circular detection pattern, with at least a 60-inch (1525-mm) radius on a continuous glass pane. Sensor element shall not be larger than 4 sq. in. (25.80 sq. cm).
 2. Hookup Cable: Factory installed, not less than 72 inches (1830 mm).
 3. Activation Indicator: LED on sensor housing that illuminates when responding to vibrations, remaining on until manually reset at sensor control unit or at master control unit.
 4. Control Unit: Integral with sensor housing or in a separate assembly, locally adjustable by control under housing cover.
 5. Glass-Break Simulator: A device to induce frequencies into protected glass pane that simulate breaking glass without causing damage to glass.

2.10 MASTER CONTROL UNIT

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work include, and are limited to, the following:
 - 1. Bosch Security Systems, Inc.
 - 2. DSC
 - 3. DMP
 - 4. Owner and Consultant approved equal.
- B. Description: Supervise sensors and detection subsystems and their connecting communication links, status control (secure or access) of sensors and detector subsystems, activation of alarms and supervisory and trouble signals, and other indicated functions.
 - 1. System software and programs shall be held in flash electrically erasable programmable read-only memory (EEPROM), retaining the information through failure of primary and secondary power supplies.
 - 2. Include a real-time clock for time annotation of events on the event recorder and printer.
 - 3. Addressable initiation devices that communicate device identity and status.
 - 4. Control circuits for operation of mechanical equipment in response to an alarm.
- C. Construction: Freestanding equipment rack or Desk-mounted console, modular, with separate and independent alarm and supervisory system modules. Alarm-initiating protected zone boards shall be plug-in cards. Arrangements that require removal of field wiring for module replacement are unacceptable.
- D. Comply with UL 609, UL 1023, UL 1076.
- E. Console Controls and Displays: Arranged for interface between human operator at master 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: LCD, two and three line(s) of 80 characters, minimum.
 - 2. Keypad: Arranged to permit entry and execution of programming, display, and control commands.
 - 3. Control-Unit Network: Automatic communication of alarm, status changes, commands, and other communications required for system operation. Communication shall return to normal after partial or total network interruption such as power loss or transient event. Total or partial signaling network failures shall identify the failure and record the failure at the annunciator display and at the system printer.
 - 4. Field Device Network: Communicate between the control unit and field devices of the system. Communications shall consist of alarm, network status, and status and control of field-mounted processors. Each field-mounted device shall be interrogated during each interrogation cycle.

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5. Operator Controls: Manual switches and push-to-test buttons that do not require a key to operate. Prevent resetting of alarm, supervisory, or trouble signals while alarm or trouble condition persists. Include the following:
 - a. Acknowledge alarm.
 - b. Silence alarm.
 - c. System reset.
 - d. LED test.
 6. Timing Unit: Solid state, programmable, 365 days.
 7. Confirmation: Relays, contactors, and other control devices shall have auxiliary contacts that provide confirmation signals to system for their on or off status. Software shall interpret such signals, display equipment status, and initiate failure signals.
 8. Alarm Indication: Audible signal sounds and an LED lights at master control unit identifying the protected zone or addressable detector originating the alarm. Annunciator panel displays a common alarm light and sounds an audible tone.
 9. Alarm Indication: Audible signal sounds and a plain-language identification of the protected zone or addressable detector originating the alarm appears on LED or LCD display at master control unit. Annunciator panel displays a common alarm light and sounds an audible tone.
 10. Alarm Indication: Audible signal sounds and a plain-language identification of the protected zone or addressable detector originating the alarm appears on LED, LCD or cathode-ray-tube display at master control unit. Annunciator panel alarm light and audible tone identify protected zone signaling an alarm.
 11. Alarm activation sounds a bell or siren and strobe.
- F. Protected Zones: Quantity of alarm and supervisory zones as indicated, with capacity for expanding number of protected zones by a minimum of 25 percent.
- G. Power Supply Circuits: Master control units shall provide power for remote power-consuming detection devices. Circuit capacity shall be adequate for at least a 25 percent increase in load.
- H. UPS: Comply with Section 26 33 53 "Static Uninterruptible Power Supply." UPS shall be sized to provide a minimum of six hours of master control-unit operation.
- I. Cabinet: Lockable, steel enclosure arranged so operations required for testing, normal operation, and maintenance are performed from front of enclosure. If more than a single cabinet is required to form a complete control unit, provide exactly matching modular enclosures. Accommodate all components and allow ample gutter space for field wiring. Identify each enclosure by an engraved, laminated, phenolic-resin nameplate. Lettering on enclosure nameplate shall not be less than 1 inch (25 mm) high. Identify, with permanent labels, individual components and modules within cabinets.
- J. Transmission to Monitoring Station: A communications device to automatically transmit alarm, supervisory, and trouble signals to the monitoring station, operating over a standard voice grade telephone leased line. Comply with UL 1635.

- 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.

2.11 AUDIBLE AND VISUAL ALARM DEVICES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work include, and are limited to, the following:
 - 1. Contractor Preference – devices to be fully compatible with chosen system manufacturer.
- B. Bell: Master control unit 10 inches (254 mm) in diameter, rated to produce a minimum sound output of 84 dB at 10 feet (3 m) from master control unit.
 - 1. Enclosure: Weather-resistant steel box equipped with tamper switches on cover and on back of box.
- C. Klaxon Weatherproof Motor-Driven Hooter: UL listed, rated to produce a minimum sound output of 120 dB at 3 feet (1 m), plus or minus 3 dB, at a frequency of 470 Hz. Rated for intermittent use: two minutes on and five minutes off.
 - 1. Designed for use in industrial areas and in high-noise, severe-weather marine environments.
- D. Siren: 30-W speaker with siren driver, rated to produce a minimum sound output of 103 dB at 10 feet (3 m) from master control unit.
 - 1. Enclosure: Weather-resistant steel box with tamper switches on cover and on back of box.
- E. Strobe: Xenon light complying with UL 1638, with a clear polycarbonate lens.
 - 1. Light Output: 115 cd, minimum.
 - 2. Flash Rate: 60 per minute.

2.12 SECURITY FASTENERS

- A. Operable only by tools produced for use on specific type of fastener by fastener manufacturer or other licensed fabricator. Drive system type, head style, material, and protective coating as required for assembly, installation, and strength.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work include, and are limited to, the following:
 - 1. Acument Global Technologies North America.
 - 2. Safety Socket LLC.

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3. Tamper-Pruf Screws.
- C. Drive System Types: Pinned Torx-Plus, pinned Torx or pinned hex (Allen).
- D. Socket Flat Countersunk Head Fasteners:
1. Heat-treated alloy steel, ASTM F 835 (ASTM F 835M).
 2. Stainless steel, ASTM F 879 (ASTM F 879M), Group 1 CW.
- E. Socket Button Head Fasteners:
1. Heat-treated alloy steel, ASTM F 835 (ASTM F 835M).
 2. Stainless steel, ASTM F 879 (ASTM F 879M), Group 1 CW.
- F. Socket Head Cap Fasteners:
1. Heat-treated alloy steel, ASTM A 574 (ASTM A 574M).
 2. Stainless steel, ASTM F 837 (ASTM F 837M), Group 1 CW.
- G. Protective Coatings for Heat-Treated Alloy Steel:
1. Zinc chromate, ASTM F 1135, Grade 3 or Grade 4, for exterior applications and interior applications where indicated.
 2. Zinc phosphate with oil, ASTM F 1137, Grade I, or black oxide unless otherwise indicated.

PART 3 EXECUTION

3.1 SYSTEM INSTALLATION

- A. Comply with UL 681 and NFPA 731.
- B. Equipment Mounting: Install master control unit on finished floor with tops of cabinets not more than 72 inches (1830 mm) above the finished floor.
1. Comply with requirements for seismic-restraint devices specified in Section 26 05 48 "Vibration and Seismic Controls for Electrical Systems."
- C. Install wall-mounted equipment, with tops of cabinets not more than 72 inches (1830 mm) above the finished floor.
1. Comply with requirements for seismic-restraint devices specified in Section 26 05 48 "Vibration and Seismic Controls for Electrical Systems."
- D. Connecting to Existing Equipment: Verify that existing perimeter security 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.

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3. Expand, modify, and supplement existing control and monitoring equipment as necessary to extend existing control and monitoring] functions to the new points. New components shall be capable of merging with existing configuration without degrading the performance of either system.
- E. Security Fasteners: Where accessible to inmates, install intrusion detection components using security fasteners with head style appropriate for fabrication requirements, strength, and finish of adjacent materials except that a maximum of two different sets of tools shall be required to operate security fasteners for Project. Provide stainless-steel security fasteners in stainless-steel materials.

3.2 WIRING INSTALLATION

- A. Wiring Method: Install wiring in metal raceways according to Section 26 05 33 "Raceways and Boxes for Electrical Systems." Conceal raceway except in unfinished spaces and as indicated. Minimum conduit size shall be 1/2 inch (13 mm). Control and data transmission wiring shall not share conduit with other building wiring systems.
- B. Wiring Method: Install wiring in metal raceways according to Section 26 05 33 "Raceways and Boxes for Electrical Systems," except in accessible indoor ceiling spaces and in interior hollow gypsum board partitions where cable may be used. Conceal raceways and wiring except in unfinished spaces and as indicated. Minimum conduit size shall be 1/2 inch (13 mm). Control and data transmission wiring shall not share conduit with other building wiring systems.
- C. Wiring Method: Cable, concealed in accessible ceilings, walls, and floors when possible.
- D. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Use lacing bars and distribution spools. Separate power-limited and non-power-limited conductors as recommended in writing by manufacturer. Install conductors parallel with or at right angles to sides and back of enclosure. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with intrusion system to terminal blocks. Mark each terminal according to system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.
- E. Wires and Cables:
 1. Conductors: Size as recommended in writing by system manufacturer unless otherwise indicated.
 2. 120-V Power Wiring: Install according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables" unless otherwise indicated.
 3. Control and Signal Transmission Conductors: Install unshielded, twisted-pair cable unless otherwise indicated or if manufacturer recommends shielded cable, according to Section 28 05 13 "Conductors and Cables for Electronic Safety and Security."
 4. Data and Television Signal Transmission Cables: Install according to Section 28 05 13 "Conductors and Cables for Electronic Safety and Security."
- F. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

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- G. Install power supplies and other auxiliary components for detection devices at control units unless otherwise indicated or required by manufacturer. Do not install such items near devices they serve.
- H. Identify components with engraved, laminated-plastic or metal nameplate for master control unit and each terminal cabinet, mounted with corrosion-resistant screws. Nameplates and label products are specified in Section 26 05 53 "Identification for Electrical Systems."

3.3 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with identification requirements in Section 26 05 53 "Identification for Electrical Systems."
- B. Install instructions frame in a location visible from master control unit.

3.4 GROUNDING

- A. Ground the master control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to master control unit.
- B. Ground system components and conductor and cable shields to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
- C. Signal Ground Terminal: Locate at main equipment rack or cabinet. Isolate from power system and equipment grounding. Provide 5 -ohm ground. Measure, record, and report ground resistance.
- D. Install grounding electrodes of type, size, location, and quantity indicated. Comply with installation requirements in Section 26 05 26 "Grounding and Bonding for Electrical Systems."

3.5 FIELD QUALITY CONTROL

- A. Pretesting: After installation, align, adjust, and balance system and perform complete pretesting to determine compliance of system with requirements in the Contract Documents. Correct deficiencies observed in pretesting. Replace malfunctioning or damaged items with new ones and retest until satisfactory performance and conditions are achieved. Prepare forms for systematic recording of acceptance test results.
 - 1. Report of Pretesting: After pretesting is complete, provide a letter certifying that installation is complete and fully operable; include names and titles of witnesses to preliminary tests.
- B. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- C. Tests and Inspections: Comply with provisions in NFPA 731, Ch. 9, "Testing and Inspections."

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1. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.
 2. Test Methods: Intrusion detection systems and other systems and equipment that are associated with detection and accessory equipment shall be tested according to Table "Test Methods" and Table "Test Methods of Initiating Devices."
- D. Documentation: Comply with provisions in NFPA 731, Ch. 4, "Documentation."
- E. Tag all equipment, stations, and other components for which tests have been satisfactorily completed.

3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain the intrusion detection system. Comply with documentation provisions in NFPA 731, Ch. 4, "Documentation and User Training."

END OF SECTION 28 1600

SECTION 28 2300 – VIDEO SURVEILLANCE

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Video surveillance system requirements.
- B. Video recording and viewing equipment.
- C. Cameras.
- D. Accessories.

1.2 RELATED REQUIREMENTS

- A. Division 07
- B. Section 27 1500 – Horizontal Cabling.
- C. Section 28 0528 – Pathways for Electronic Safety and Security.
- D. Section 26 0553 - Identification for Electrical Systems: Identification products and requirements.
- E. State of NM DoIT – Standard for Building and Campus Distribution Systems

1.3 REFERENCE STANDARDS

- A. 47 CFR 15 - Radio Frequency Devices; current edition.
- B. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.
- C. NECA 303 - Standard for Installing Closed-Circuit Television (CCTV) Systems; 2005.
- D. NFPA 70 - National Electrical Code; 2017.

1.4 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate the placement of cameras in the field with the Owner.
 - 2. Coordinate the placement of cameras with structural members, ductwork, piping, equipment, luminaires, diffusers, fire suppression system components, and other potential conflicts installed under other sections or by others.

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3. Coordinate the work with other installers to provide power for cameras and equipment at required locations.
 4. Notify Architect of any conflicts with or deviations from the contract documents. Obtain direction before proceeding with work.
- B. Pre-installation Meetings:
1. Conduct meeting with Owner to review camera and equipment locations and camera field of view objectives.
- C. Contractor-Furnished Products: Cameras, camera mounts, camera data storage equipment, POE switches for cameras, camera licenses, camera and network software, camera surge suppression, and computers.
1. All additional provisions, wiring, raceways, boxes and general equipment shall also be provided and installed by the Contractor.
 2. program, integrate and certify the Video Surveillance system

1.5 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Shop Drawings: Include plan views indicating locations of system components and proposed size, type, and routing of conduits and/or cables. Include elevations and details of proposed equipment arrangements. Include system interconnection schematic diagrams. Include requirements for interface with other systems.
- C. Product Data: Provide manufacturer's standard catalog pages and data sheets for each system component. Include ratings, configurations, standard wiring diagrams, dimensions, finishes, service condition requirements, and installed features.
- D. Evidence of qualifications for installer.
- E. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and operation of product.
- F. Field quality control test reports.
- G. Project Record Documents: Record actual locations of system components and installed wiring arrangements and routing.
- H. Warranty: Submit sample of manufacturer's warranty and documentation of final executed warranty completed in Owner's name and registered with manufacturer.

1.6 QUALITY ASSURANCE

- A. Comply with the following:
 - 1. NFPA 70.
 - 2. Applicable TIA/EIA standards.
- B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.
- C. Installer Qualifications: Company specializing in performing the work of this section with minimum three years documented experience with video surveillance systems of similar size, type, and complexity and providing contract maintenance service as a regular part of their business; authorized manufacturer's representative.

1.7 PROGRAMMING

- A. The contractor shall engage the Design Team, Owner and Architect to schedule a pre-submittal meeting to review programming and unique project requirements to ensure system components and configurations are in line with owner requirements.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store products in accordance with manufacturer's instructions and NECA 303.
- B. Store products in manufacturer's unopened packaging, keep dry and protect from damage until ready for installation.

1.9 FIELD CONDITIONS

- A. Maintain field conditions within manufacturer's required service conditions during and after installation.

1.10 WARRANTY

- A. See Section 01 7800 - Closeout Submittals, for additional warranty requirements.
- B. Provide minimum one year manufacturer warranty covering repair or replacement due to defective materials or workmanship.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Cameras: Avigilon, A Motorola Company
 - 1. Substitutions: Owner and Consultant approved equal or better.

2.2 VIDEO SURVEILLANCE SYSTEM

- A. Design and provide video surveillance system consisting of but not limited to, Owner-furnished products; and conduit, boxes, wiring, connectors, accessories, 8 port EDS switch, PoE+ Managed Switches, UPS, etc. as necessary for a complete operating system that provides the functional intent indicated and is a unified solution with the Access Control system.
- B. System Description: IP system with connection to network (IP) cameras.
 - 1. System shall provide high-quality delivery and processing of IP-based video, audio, and control data using standard Ethernet-based networks.
 - 2. System shall have seamless integration of all video surveillance and control functions.
 - 3. Graphical user interface software shall manage all IP-based video matrix switching and camera control functions, two-way audio communication, alarm monitoring and control, and recording and archive/retrieval management. IP system shall also be capable of integrating into larger system environments.
 - 4. System design shall include all necessary compression software for high-performance, dual-stream and MPEG-2/MPEG-4 video. Unit shall provide connections for all video cameras, camera PTZ control data, bidirectional audio, discreet sensor inputs, and control system outputs.
 - 5. All camera signals shall be compressed, encoded, and delivered onto the network for processing and control by the IP video-management software.
 - 6. Camera system units shall be ruggedly built and designed for extreme adverse environments, complying with NEMA Type environmental standards.
 - 7. Encoder/decoder combinations shall place video, audio, and data network stream that can be managed from multiple workstations on the user's LAN or WAN.
 - 8. All system interconnecting cables, workstation PCs, and network intermediate devices shall be provided for full performance of specified system.
 - 9. Surge Protection: Provided by Owner.
- C. Video Recording and Viewing Equipment Required:
 - 1. See article "VIDEO RECORDING AND VIEWING EQUIPMENT" below for product descriptions.
- D. Interface with Other Systems:

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1. Provide products compatible with other systems requiring interface with video surveillance system, Access Control and Building Intrusion.
- E. Provide products listed, classified, and labeled as suitable for the purpose intended.
- F. Electromagnetic Interference/Radio Frequency Interference (EMI/RFI) Limits: Comply with FCC requirements of 47 CFR 15, for Class B, consumer application.

2.3 COLOR MONITORS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include the following:
 1. Contractor Preference
 - a. Base Requirements
 - b. Resolution – 1080p
 - c. Size – 27” Diagonal
 - d. Inputs – HDMI, Display Port and DVI

2.4 VIDEO RECORDING AND VIEWING EQUIPMENT

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include the following:
 1. Avigilon, A Motorola Company
- B. Minimum Load Rating: Rated for load in excess of the total weight supported times a minimum safety factor of two.
- C. Mounting Brackets for Fixed Cameras: Type matched to items supported and mounting conditions. Include manual pan-and-tilt adjustment.
 1. Tamper switch on access cover sounds an alarm signal when unit is opened or partially disassembled. Central-control unit shall identify tamper alarms and indicate location in alarm display.
 2. Camera Viewing Window: Polycarbonate, Lexan window, aligned with camera lens.
 3. Duplex Receptacle: Internally mounted.
 4. Alignment Provisions: Camera mounting shall provide for field aiming of camera and permit removal and reinstallation of camera lens without disturbing camera alignment.
 5. Built-in, thermostat-activated heater and blower units. Units shall be automatically controlled so the environmental limits of the camera equipment are not exceeded. (Exterior camera locations)
 6. Mounting bracket and hardware for wall or ceiling mounting of the housing. Bracket shall be of same material as the housing; mounting hardware shall be stainless steel.
 7. Finish: Housing and mounting bracket shall be factory finished using manufacturer's standard finishing process suitable for the environment.

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8. Enclosure Rating: NEMA 250, Type 1, Type 3, Type 4X. Shall be designed and installed per manufacturers' guidelines and in accordance with environmental conditions.

D. IP Video Controls:

1. Keyboards, KVM switches, local Ethernet switches, and aggregating switch: Provided by Owner.

E. Software:

1. Unless otherwise indicated, provide all software and licenses required for a fully operational system.
2. Software and licenses required for fully operational system:
 - a. Cisco/Meraki VMS Solution

2.5 NETWORK VIDEO RECORDER/SERVERS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include the following:
- a. Avigilon, A Motorola Company
 - 1) A rack mounted NVR, with ACC loaded software.

2.6 SIGNAL TRANSMISSION COMPONENTS

A. OSP Cabling

1. GameChanger Category 6 cable as mfg by Paige DataComm

B. Media Convertor

1. Media Convertors may be required for converting media types for pole mounted site cameras that exceed the Category Cable distance of 100m (328 feet).
2. Power for media convertors will be provide at the pole location.

C. Media Extenders

1. Media Extenders may be used to extend Category Cable to camera locations where the cable run exceeds the 100m (328ft) rule.
2. Power for Media Extenders should be provided by POE+ or POE++ switches located in telecom rooms.
3. Manufacturer: Contractor Preference.
4. Media extenders should be DIN rail mounted or Rack mounted to provide an accessible location in the telecom rooms.
5. OSP Category Cable is required for any cable run that goes from extender to camera location.

2.7 ACCESSORIES

- A. Provide components as required for connection of video surveillance system to devices and other systems, as required.
- B. Provide network switches as required for network connections to system components
 - 1. PoE + Managed, 24 Port, Rack Mount Switch (CFCI)
 - 2. 802.3at, Layer 2 (minimum)
 - 3. PoE Budget – 380W/720W EPS
 - 4. Redundant Power Supply
 - 5. Smart PoE power distribution
- C. Provide network surge protection for all exterior devices:
 - 1. OSP Surge Protection
 - a. Rack mount surge protector for shielded Ethernet, PoE and optional PoE extender circuits
 - b. Manufacturers:
 - c. Ditek
 - d. L-Com
 - 2. Surge Current Capacity
 - a. 20kA
 - 3. Protection Modes
 - a. L-G (All), L-L (All))
- D. Cabling and Wire: Provide cables as indicated or as required for connections between system components.
 - 1. Products:
 - a. Shall match Category Cable Manufacturer submitted under Div. 271500
 - b. OSP Cable, see Item 5 below.
 - 2. Wire Size: Provide sufficient wire gage to limit voltage drop to 5 percent.
 - 3. Camera Power Wiring: Interior cameras will be Powered over Ethernet (PoE). Provide 120 VAC UPS power for cameras connected by optic fiber or where otherwise required for operation.
 - 4. IP Camera Wiring: Provide Category 6 cabling from each IP video device to the nearest switch.
 - 5. OSP Camera Wiring: Provide OSP Gamechanger Category 6 Cable as manufactured by Paige DataComm.
- E. Provide accessory racks/cabinets as indicated or as required for equipment mounting.

- F. Provide heater/blower units for exterior cameras where applicable.

PART 3 EXECUTION

3.1 COORDINATION

- A. Preliminary Coordination: Coordinate required embeds and block-outs as required to install cameras as indicated.

3.2 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that ratings and configurations of system components are consistent with the indicated requirements.
- C. Verify that mounting surfaces are ready to receive system components.
- D. Verify that branch circuit wiring installation is completed, tested, and ready for connection to system.
- E. Verify that conditions are satisfactory for installation prior to starting work.
- F. Construction Examination: Monitor ongoing construction and coordinate with other trades so that a clear line of site of the area to be viewed is maintained for each camera.
- G. Structural Examination: Examine locations for camera mounts and poles to ensure the supporting structures will carry camera mounts and devices to be installed.

3.3 INSTALLATION

- A. Install video surveillance system in accordance with NECA 1 (general workmanship) and NECA 303.
- B. Install products in accordance with manufacturer's instructions.
- C. Wiring Method: Unless otherwise indicated, use wiring in conduit.
 - 1. Conduits:
 - a. New construction: Use concealed conduits.
 - b. Route exposed conduits parallel or perpendicular to building structural members and surfaces.
 - 2. Use suitable listed cables in wet locations, including underground raceways.
 - 3. Use suitable listed cables for vertical riser applications.
 - 4. Conceal connecting cables to cameras in the mount or install with flexible conduit; Flexible conduit not allowed in inmate housing areas.

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5. Conduit: Comply with Division 28.

D. Special Boxes: Furnish and install special back boxes in a timely manner for field installation while adequate access is available.

E. Camera Conduit/Boxes:

1. Drops for each security camera as indicated on drawings.

2. Drops to be mounted in box above drop ceiling.

F. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified in Section 07 8400.

G. Identify system wiring and components in accordance with Section 26 0553.

H. Field Wiring: The wiring that extends from the electronic control relay terminal strips to the locks, lights, etc. shall be class 1, 2, or 3 as defined by Article 725 of the National Electric Code.

3.4 FIELD QUALITY CONTROL

A. See Section 01 4000 - Quality Requirements, for additional requirements.

B. Titles: Program camera identifications and intercom call up titles as approved by the Owner.

C. Assist Owner to prepare and start system in accordance with manufacturer's instructions.

D. Adjust cameras to provide desired field of view and produce suitable images under all service lighting conditions.

E. Test for proper interface with other systems.

F. Correct defective work, adjust for proper operation, and retest until entire system complies with contract documents.

G. Submit detailed reports indicating inspection and testing results and corrective actions taken.

3.5 CLEANING

A. Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

3.6 CLOSEOUT ACTIVITIES

A. See Section 01 7800 - Closeout Submittals, for closeout submittals.

B. See Section 01 7900 - Demonstration and Training, for additional requirements.

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- C. Demonstration: Demonstrate proper operation of system to Owner, and correct deficiencies or make adjustments as directed.
- D. Present to the owner in writing any reoccurring software, hardware or device reoccurring maintenance or operational charges/fees.

3.7 PROTECTION

- A. Protect installed system components from subsequent construction operations.

END OF SECTION

SECTION 28 3111 - DIGITAL, ADDRESSABLE FIRE-ALARM SYSTEM

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. The existing Albuquerque Studios are being expanded, including construction of new buildings. The existing fire alarm system manufacturer is Notifier. The fire alarm system for the new buildings will have distributed fire alarm control units (FACU) at each building, with all FACU's networked together via a fiber optic data network. The expanded/new system shall be interconnected to the existing system. The new system will incorporate emergency voice communication/mass notification.
- B. This Section includes fire alarm systems, including manual stations, detectors, signal equipment, controls, and devices. Fire alarm system design shop drawings and plans 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 City of Albuquerque Fire Marshal's Office, and all additional requirements as indicated on the plans and specifications. The shop drawings shall be approved by the City of Albuquerque. Refer to additional submission requirements below. The fire alarm system and all devices shall be compatible with the existing campus fire alarm system (Notifier ONXY). Include cost to program all new devices on the existing Notifier ONYXworks network including firmware revisions, up-dates existing workstations, updates existing, NCA-2 updates. Provide Notifier NFS2-3030, Digital voice command (DVC) emergency voice system. Section Includes:
 - 1. Notifier NFS2 3030 with DVC emergency voice system.
 - 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.

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.

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- 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/pressurization 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, 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. Manufacture certification being a "Notifier" Authorize Premiere Distributor for the Albuquerque area.
 - e. Installing Fire Alarm Contractor is UL Certificate for Alarm System with Underwriters Laboratories Inc.
- 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 for high-rise application.
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 Albuquerque Fire Marshal's Office shall meet all requirements stated in the current high-rise codes and Presbyterian Health Service additional standards. Include design by a NICET Level III/IV technician as part of the preparation and submission of the shop

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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 City of Albuquerque Fire Marshal's Office.

- 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.

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- 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 2 percent of amount of each type installed, but no fewer than one unit of each type.
 - 4. Keys and Tools: One extra set for access to locked or tamper proofed components.
 - 5. Audible and Visual Notification Appliances: One of each type installed.

1.8 QUALITY ASSURANCE

- A. Installer Qualifications: Personnel shall be trained and certified by Notifier for installation of units required for this Project.
- B. Installer Qualifications: Installation shall be by personnel certified by NICET as fire-alarm Level I or II 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.

1.9 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.

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1. Warranty Extent: All equipment and components not covered in the Maintenance Service Agreement.
2. Warranty Period: Five years from date of Substantial Completion.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Manufacturers: Subject to compliance with requirements, provide the following products by Notifier:
 - B. Automatic sensitivity control of certain smoke detectors.
 - C. All components provided shall be listed for use with the selected system.
 - 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.

2.2 SYSTEMS OPERATIONAL DESCRIPTION

- A. Fire-alarm signal initiation shall be by one or more of the following devices and systems:
 1. Manual stations.
 2. Heat detectors.
 3. Smoke detectors.
 4. Duct smoke detectors.
 5. Carbon monoxide detectors.
 6. 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.

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7. Switch heating, ventilating, and air-conditioning equipment controls to fire-alarm mode.
 8. Activate stairwell and elevator-shaft pressurization systems via SCS Workstation.
 9. Close smoke dampers in air ducts of designated air-conditioning duct systems.
 10. Activate pre-action system.
 11. Recall elevators to primary or alternate recall floors.
 12. Activate elevator power shunt trip.
 13. Activate emergency lighting control.
 14. Activate emergency shutoffs for gas and fuel supplies.
 15. Record events in the system memory.
 16. Record events by the system printer.
 17. 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 pre-action 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.

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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.

2.3 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Fire-alarm control unit and raceways shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.4 FIRE-ALARM CONTROL UNITS

- A. Notifier NFS2-3030 with DVC digital voice (no exceptions) non-coded, UL-certified addressable system, with multiplexed signal transmission, emergency voice notification and network capable to existing campus network.
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.

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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 160 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. Notification: Voice alarm system using speaker strobe appliances.
 2. Pathway Class Designations: NFPA 72, Class A for SLC, IDC and NAC circuits.
 3. Install no more than 85% addressable devices on each signaling-line circuit.
 4. Serial Interfaces:
 - a. One dedicated RS 485 port for central-station operation using point ID DACT.
 - b. One RS 485 port for remote annunciators, Ethernet module, or multi-interface module (printer port).
 - c. One USB 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.

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5. Cancel fire-alarm control unit indication and system reset if the alarm is not verified.
- F. 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.
- G. 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.
- H. 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.
- I. 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.
- J. 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.
1. Alarm current draw of entire fire-alarm system shall not exceed 80 percent of the power-supply module rating.
- K. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.
1. Batteries: Sealed lead calcium.
- L. Instructions: Computer printout or typewritten instruction card mounted behind a plastic or glass cover in a stainless-steel or aluminum frame. Include interpretation and describe

appropriate response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions.

2.5 NOTIFIER ONYX WORKSTATION & NETWORK ANNUNCIATOR

2.6 NOTIFIER ADDRESSABLE BI-DIRECTIONAL AMPLIFIER (BDA) TWO-WAY EMERGENCY RADIO COMMUNICATION (NOTIFIER NF-BDA800-IB)

2.7 MANUAL FIRE-ALARM BOXES (Notifier NBG-12LX)_

- 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.

2.8 SYSTEM SMOKE DETECTORS (Notifier FSP-951)

- A. General Requirements for System Smoke Detectors:
- B. Comply with UL 268; operating at 24-V dc, nominal.
1. Detectors shall be four-wire type.
 2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
 3. 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.
 4. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
 5. Integral Visual-Indicating Light: LED type, indicating detector has operated and power-on status.

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6. 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.
 7. 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.
 8. 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.(Notifier DNR Series)
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.

2.9 PROJECTED BEAM SMOKE DETECTORS (Notifier FS-OSI-RI)

- 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.).

2.10 CARBON MONOXIDE DETECTORS (Notifier FCO-951)

- A. General: Carbon monoxide detector listed for connection to fire-alarm system.
 - 1. Mounting: Adapter plate for outlet box mounting.
 - 2. Testable by introducing test carbon monoxide into the sensing cell.
 - 3. Detector shall provide alarm contacts and trouble contacts.
 - 4. Detector shall send trouble alarm when nearing end-of-life, power supply problems, or internal faults.
 - 5. Comply with UL 2075.
 - 6. Locate, mount, and wire according to manufacturer's written instructions.
 - 7. Provide means for addressable connection to fire-alarm system.
 - 8. Test button simulates an alarm condition.

2.11 MULTICRITERIA DETECTORS (Notifier FSC-951)

- 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:

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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.
- G. **HEAT DETECTORS (Notifier FST-951 Series)**
1. General Requirements for Heat Detectors: Comply with UL 521
 - a. Temperature sensors shall test for and communicate the sensitivity range of the device.
 2. 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.
 - 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.
- H. 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.
- I. 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. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.
 3. Flashing shall be in a temporal pattern, synchronized with other units.
 4. Strobe Leads: Factory connected to screw terminals.
 5. Mounting Faceplate: Factory finished, white.

2.12 NOTIFICATION-APPLIANCE:(NOTIFIER/SYSTEM SENSOR SERIES SPEAKER/STROBES UNITS)

- A. Audible appliances shall sound in a three-pulse temporal pattern, as defined in NFPA 72.
- B. Visual alarm appliances shall flash in synchronization where multiple appliances are in the same field of view, as defined in NFPA 72.

2.13 MAGNETIC DOOR HOLDERS (Provided by Door hardware Contractor)

- 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.
- B. Material and Finish: Match door hardware.

2.14 GRAPHIC ANNUNCIATORS (Notifier ONYX-Works Workstation)

- 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.

2.15 REMOTE ANNUNCIATORS (Notifier LCD-160)

- A. Description: Annunciator functions shall match those of fire-alarm control unit for alarm, supervisory, and trouble indications. Manual switching functions shall match those of fire-alarm control unit, including acknowledging, silencing, resetting, and testing.
 - 1. Mounting: Flush cabinet, NEMA 250, Type 1.
- B. Display Type and Functional Performance: Alphanumeric display and LED indicating lights shall match those of fire-alarm control unit. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

2.16 ADDRESSABLE INTERFACE DEVICE (Notifier FMM-1 FRM-1-FCM-1)

- 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.

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- 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.

2.17 DIGITAL ALARM COMMUNICATOR TRANSMITTER (Notifier UDACT-2)

- 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.

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- 7. Abnormal test signal.
- 8. Communication bus failure.
- E. Secondary Power: Integral rechargeable battery and automatic charger.
- F. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

2.18 NETWORK COMMUNICATIONS (Extend to Central Plant & POB-2)

- 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.

2.19 SYSTEM PRINTER

- A. Printer shall be listed and labeled as an integral part of fire-alarm system.

2.20 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.

2.21 FIRE ALARM WIRE AND CABLE (Installed in complete class-A raceways-dedicated SLC & aux power circuits and separate dedicated raceway for notification circuits)

- A. General Wire and Cable Requirements: NRTL listed and labeled as complying with NFPA 70, Article 760.
- B. Signaling Line Circuits: Twisted, 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. 18 AWG, minimum, in pathway.
 - 2. Line-Voltage Circuits: No. 12 AWG, minimum, in pathway.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions for compliance with requirements for ventilation, temperature, humidity, and other conditions affecting performance of the Work.
 - 1. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment and wiring are installed, before installation begins.
- B. Examine roughing-in for electrical connections to verify actual locations of connections before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 EQUIPMENT INSTALLATION

- A. Comply with NFPA 72, NFPA 101, 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 campus networked FACPs Remote network annunciators and network workstations
 - 2. 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. Upgrade existing firmware to current revision matching new equipment in the patient tower
- 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.

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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.

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- 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.

3.3 PATHWAYS

- A. Pathways shall be installed in EMT.(Dedicated raceway SLC & Aux Power circuits & dedicated raceway NAC circuits)
- B. EMT shall be painted red enamel.

3.4 CONNECTIONS

- A. For fire-protection systems related to doors in fire-rated walls and partitions and to doors in smoke partitions, comply with requirements in Section 087100 "Door Hardware." Connect hardware and devices to fire-alarm system.
 - 1. Verify that hardware and devices are listed for use with installed fire-alarm system before making connections.
- B. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 36 inches from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.
 - 1. Alarm-initiating connection to smoke-control system (smoke management) at firefighters' smoke-control system panel.
 - 2. Alarm-initiating connection to stairwell and elevator-shaft pressurization systems.
 - 3. Smoke dampers in air ducts of designated HVAC duct systems.
 - 4. Magnetically held-open doors.
 - 5. Electronically locked doors and access gates.
 - 6. Alarm-initiating connection to elevator recall system and components.

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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 emergency voice 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.

3.5 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.

3.6 GROUNDING

- A. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.
- B. Ground shielded cables at the control panel location only. Insulate shield at device location.

3.7 FIELD QUALITY CONTROL

- A. Field tests shall be witnessed by Architect or owners representative.
- 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.

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- 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. 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.

3.8 MAINTENANCE SERVICE

- A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by skilled employees of manufacturer's designated service organization. Include preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
 - 1. Include visual inspections according to the "Visual Inspection Frequencies" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
 - 2. Perform tests in the "Test Methods" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
 - 3. Perform tests per the "Testing Frequencies" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

3.9 SOFTWARE SERVICE AGREEMENT

- A. Comply with UL 864.

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- B. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.
- C. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.
 - 1. Upgrade Notice: At least 30 days to allow Owner to schedule access to system and to upgrade computer equipment if necessary.

3.10 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fire-alarm system.

END OF SECTION

SECTION 31 00 00 - 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. Project Geotechnical Investigation.
- 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.

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- D. 2015 INTERNATIONAL BUILDING CODE (IBC)
 - 1. Chapter 18 – Soils and Foundation
- E. NEW MEXICO STANDARD SPECIFICATIONS, LATEST EDITION, INCLUDING ALL UPDATES, AND ALL APPLICABLE LAWS, CODES, AND REGULATIONS.

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: New Mexico Standard Specifications, Section 302.
- B. Refer to Geotech Report for backfill requirements.

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 the 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.

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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.

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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 in accordance with the project geotechnical investigation 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

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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**

SECTION 32 1200 - FLEXIBLE PAVING

PART 1 – GENERAL

1.1 RELATED REQUIREMENTS:

- A. Any New Mexico 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 for Highway and Bridge Construction, 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 JOB CONDITIONS

- A. Weather Limitations
 - 1. Apply prime and tack coats when ambient temperature is above 40°, and when temperature has been above 35° for 12 hours immediately prior to application. Do not apply when subgrade is wet or contains excess moisture.
 - 2. Construct asphalt concrete paving when atmospheric temperature is above 40° 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 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.

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- C. Asphalt Cement: Comply with AASHTO M 320.
- D. Asphalt-Aggregate Mixture: per New Mexico Department of Transportation Specifications, Section 423

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. Tack Coat
 - 1. Apply bituminous tack coat to all base asphalt material surfaces where asphalt concrete paving will be constructed.
 - 2. Apply bituminous tack coat in accordance with New Mexico Department of Transportation Standard Specifications, Section 407.
 - 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.

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- 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 Contractor, 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

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course for smoothness, using 10' - 0" straightedge applied parallel with, and at right angles to centerline of paved area. The results of these tests shall be made available to the owner upon request. Surfaces will not be acceptable if exceeding following tolerances for smoothness:

Subgrade: 1/2"

Wearing Course Surface: 3/16"

- D. Check surface areas at intervals necessary to eliminate ponding areas. Remove and replace unacceptable paving as directed by Owner.

END OF SECTION

SECTION 32 1300 – CONCRETE PAVEMENT, CURB, AND SIDEWALK

PART 1 GENERAL

1.1 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)

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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

D. Section 01 8113 - Sustainable Design Requirements: Project to obtain LEED Silver certification based on USGBC's "LEED Version 4 for Schools New Construction and Major Renovations."

1.3 SUBMITTALS

- A. Mix Design: For each concrete mix to be utilized.
- B. Material certificates and test reports.
- C. The General Contractor and the Subcontractor shall execute the Conformance Submittal(s) at the end of this section.

PART 2 PRODUCTS

2.1 STEEL REINFORCEMENT

- A. The type of steel reinforcement shall be as shown on the drawings.

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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 60, 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.
 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.

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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. Crafcro 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. Crafcro Inc. "ROADSAVER 22"; W.R. Meadows, Inc. "SEALTIGHT HI-SPEC".

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- 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.
 - 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.
 - 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 1 inch 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 6 feet on center.
 - d. Provide 1/2 inch expansion joints for curb and gutter and sidewalk at 60 feet on center.
 - 2. Tied construction joints: As indicated on drawings.

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3. Control joints: Depth shall be equal to $\frac{1}{4}$ 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 $\frac{1}{2}$ hour, except where such placements terminate at expansion joints. Provide $\frac{1}{4}$ " x $4\frac{1}{2}$ " 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 $\frac{1}{2}$ inch or more than 1 inch 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.
 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.

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- 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.
 - 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.
- D. See Section 01 8113 – Sustainable Design Requirements, for LEED requirements.

END OF SECTION

SECTION 32 1313 - CONCRETE PAVING

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Concrete sidewalks.

1.2 RELATED REQUIREMENTS

- A. Section 03 3000 - Cast-in-Place Concrete.
- B. Section 07 9200 - Joint Sealants: Sealing joints.

1.3 REFERENCE STANDARDS

- A. ACI 211.1 - Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete; 1991 (Reapproved 2009).
- B. ACI 301 - Specifications for Structural Concrete; 2016.
- C. ACI 304R - Guide for Measuring, Mixing, Transporting, and Placing Concrete; 2000 (Reapproved 2009).
- D. ACI 305R - Guide to Hot Weather Concreting; 2010.
- E. ACI 306R - Guide to Cold Weather Concreting; 2016.
- F. ASTM C39/C39M - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens; 2018.
- G. ASTM C94/C94M - Standard Specification for Ready-Mixed Concrete; 2017a.
- H. ASTM C685/C685M - Standard Specification for Concrete Made by Volumetric Batching and Continuous Mixing; 2014.
- I. ASTM D1751 - Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types); 2004, with Editorial Revision (2013).

1.4 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide data on joint filler, admixtures, and curing compound.

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- C. Samples: Submit two sample panels, 12 by 12 inch in size illustrating exposed aggregate finish.

PART 2 PRODUCTS

2.1 FORM MATERIALS

- A. Form Materials: As specified in Section 03 3000, conform to ACI 301.

2.2 REINFORCEMENT

- A. Reinforcing Steel and Welded Wire Reinforcement: Types specified in Section 03 3000.

2.3 CONCRETE MATERIALS

- A. Concrete Materials: As specified in Section 03 3000.

2.4 ACCESSORIES

- A. Slab Isolation Joint Filler: 1/2 inch thick, height equal to slab thickness, with removable top section that will form 1/2 inch deep sealant pocket after removal.
 - 1. Material: ASTM D1751, cellulose fiber.

2.5 CONCRETE MIX DESIGN

- A. Proportioning Normal Weight Concrete: Comply with ACI 211.1 recommendations.
- B. Concrete Strength: Establish required average strength for each type of concrete on the basis of field experience or trial mixtures, as specified in ACI 301.
 - 1. For trial mixtures method, employ independent testing agency acceptable to Architect for preparing and reporting proposed mix designs.

2.6 MIXING

- A. On Project Site: Mix in drum type batch mixer, complying with ASTM C685/C685M. Mix each batch not less than 1-1/2 minutes and not more than 5 minutes.
- B. Transit Mixers: Comply with ASTM C94/C94M.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify compacted subgrade is acceptable and ready to support paving and imposed loads.
- B. Verify gradients and elevations of base are correct.

3.2 PREPARATION

- A. Moisten base to minimize absorption of water from fresh concrete.

3.3 FORMING

- A. Place and secure forms to correct location, dimension, profile, and gradient.

3.4 REINFORCEMENT

- A. Place reinforcement as indicated.

3.5 COLD AND HOT WEATHER CONCRETING

- A. Follow recommendations of ACI 305R when concreting during hot weather.
- B. Follow recommendations of ACI 306R when concreting during cold weather.
- C. Do not place concrete when base surface temperature is less than 40 degrees F, or surface is wet or frozen.

3.6 PLACING CONCRETE

- A. Place concrete in accordance with ACI 304R.
- B. Ensure reinforcement, inserts, embedded parts, formed joints are not disturbed during concrete placement.
- C. Place concrete continuously over the full width of the panel and between predetermined construction joints. Do not break or interrupt successive pours such that cold joints occur.

3.7 JOINTS

- A. Align curb, gutter, and sidewalk joints.

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3.8 FINISHING

- A. Area Paving: Light broom, texture perpendicular to pavement direction.
- B. Sidewalk Paving: Light broom, texture perpendicular to direction of travel with troweled and radiused edge 1/4 inch radius.

3.9 FIELD QUALITY CONTROL

- A. An independent testing agency will perform field quality control tests, as specified in Section 01 4000 - Quality Requirements.
 - 1. Provide free access to concrete operations at project site and cooperate with appointed firm.
- B. Compressive Strength Tests: ASTM C39/C39M; for each test, mold and cure three concrete test cylinders. Obtain test samples for every 100 cu yd or less of each class of concrete placed.
 - 1. Take one additional test cylinder during cold weather concreting, cured on job site under same conditions as concrete it represents.
- C. Maintain records of placed concrete items. Record date, location of pour, quantity, air temperature, and test samples taken.

3.10 PROTECTION

- A. Immediately after placement, protect pavement from premature drying, excessive hot or cold temperatures, and mechanical injury.
- B. Do not permit pedestrian traffic over pavement until 75 percent design strength of concrete has been achieved.

END OF SECTION

SECTION 32 1316 - DECORATIVE CONCRETE PAVING

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Integral color and specialty finishes for concrete paving.

1.2 RELATED REQUIREMENTS

- A. Section 03 3000 - Cast-in-Place Concrete.
- B. Section 07 9200 - Joint Sealants: Sealing joints.
- C. Division 31 - Earthwork.

1.3 REFERENCE STANDARDS

- A. ACI 117 - Standard Specifications for Tolerances for Concrete Construction and Materials; 2010 (Reapproved 2015).
- B. ACI 211.1 - Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete; 1991 (Reapproved 2009).
- C. ACI 304R - Guide for Measuring, Mixing, Transporting, and Placing Concrete; 2000 (Reapproved 2009).
- D. ACI 305R - Guide to Hot Weather Concreting; 2010.
- E. ACI 306R - Guide to Cold Weather Concreting; 2016.
- F. ASTM C1116/C1116M - Standard Specification for Fiber-Reinforced Concrete; 2010a (Reapproved 2015).
- G. ASTM C94/C94M - Standard Specification for Ready-Mixed Concrete; 2017a.
- H. ASTM C150/C150M - Standard Specification for Portland Cement; 2018.
- I. ASTM C260/C260M - Standard Specification for Air-Entraining Admixtures for Concrete; 2010a (Reapproved 2016).
- J. ASTM C494/C494M - Standard Specification for Chemical Admixtures for Concrete; 2017.
- K. ASTM C685/C685M - Standard Specification for Concrete Made by Volumetric Batching and Continuous Mixing; 2014.

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- L. ASTM C979/C979M - Standard Specification for Pigments for Integrally Colored Concrete; 2016.
- M. ASTM D1751 - Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types); 2004, with Editorial Revision (2013).
- N. ASTM D1752 - Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction; 2004a (Reapproved 2013).
- O. ASTM D3405 - Standard Specification for Joint Sealants, Hot-applied, for concrete and Asphalt Pavements.
- P. ASTM D5249 - Standard Specification for Backer Material for Use with Cold and Hot-applied Joint Sealants in Portland Cement Concrete and Asphalt Joints
- Q. ASTM D5893 - Standard Specification for Cold-applied, Single Component, Chemically Curing Silicone Sealant for Portland Cement Concrete Pavements.

1.4 SUBMITTALS

- A. Mix Design: For each decorative concrete mix to be utilized.
- B. Product Data: Provide data on joint filler, admixtures, and curing compound.
- C. Samples: Submit two sample panels, 12 by 12 inch in size illustrating each type of concrete color and finish.
- D. Material certificates and test reports.
- E. Field quality control test reports.
- F. Qualifications information.

1.5 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: manufacturer of ready-mixed concrete products complying with ASTM C94/C94M requirements for production facilities and equipment.
- B. Installer Qualifications: an experienced installer who has completed pavement work similar in material, design, and extent to that indicated for this Project and whose work has resulted in construction with a record of successful in-service performance.
- C. Independent Testing Agency: qualified independent testing agency that has experience and a successful record of performing material evaluation tests and designing concrete mixes.

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- D. Source Limitations: Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant and each aggregate from one source.
- E. Contractor shall familiarize himself with existing conditions including the Geotechnical Report for this project, which includes recommendations for construction.
- F. Mock-Ups:
 - 1. Cast mockups of full-size sections 2 by 2 feet of decorative cement concrete pavement to demonstrate typical pattern, texture, surface finish, color, joints, and standard of workmanship.
 - 2. Build mockups in the location and of the size indicated or, if not indicated, as directed by Architect.
 - 3. In presence of Architect, demonstrate methods used for construction, including forming and finishing conditions required for Project using materials, workmanship, joint treatments, and curing methods to be used throughout the project.
 - 4. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

PART 2 PRODUCTS

2.1 FORM MATERIALS

- A. Wood form material, profiled to suit conditions.
- B. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and will not impair subsequent treatments of concrete surfaces

2.2 REINFORCEMENT

- A. The type of steel reinforcement shall be as shown on the drawings.

2.3 CONCRETE MATERIALS

- A. Obtain cementitious materials from same source throughout.
- B. Concrete Materials: As specified in Section 32 1313.
- C. Portland Cement: ASTM C150/C150M, Type I, II or III.
- D. Water: Clean, and not detrimental to concrete.
- E. Air-Entraining Admixtures: ASTM C260/C260M.

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- F. Chemical Admixtures: ASTM C494/C494M, Type A - Water Reducing, Type D - Water Reducing and Retarding, Type E - Water Reducing and Accelerating, and Type F - Water Reducing, High Range.
- G. Calcium Chloride: The use of calcium chloride or admixtures containing more than 0.05% chloride ions is prohibited.
- H. Color Additives:
 - 1. Color Pigment: ASTM C979/C979M, synthetic mineral-oxide pigments or colored water-reducing admixtures; color stable, free of carbon black, nonfading, and resistant to lime and other alkalis.
 - 2. Basis of Design: Davis Colors.
 - a. Integral color for decorative concrete paving: As selected by Architect.

2.4 ACCESSORIES

- A. Curing Materials:
 - 1. General:
 - a. Products shall be compatible with decorative concrete color and finish products and processes.
 - b. Products must be approved by color additive manufacturer for use with integrally colored concrete and decorative concrete.
 - c. Do not use white-pigmented compounds on integrally colored concrete.
 - 2. Curing Compound Basis of Design: Davis Colors W-10000 Clear Cure & Seal.
 - 3. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 9 oz. /sq. yd. dry;
 - 4. Moisture Curing Blankets: Disposable curing blankets designed to be used on colored of decorative concrete, and to keep the surface of concrete moist for seven days.
 - 5. Water: potable.

2.5 CONCRETE MIX DESIGN

- A. Proportioning Normal Weight Concrete: Comply with ACI 211.1 and ACI 304R recommendations.
- B. Admixtures: Add acceptable admixtures as recommended in ACI 211.1 and at rates recommended by manufacturer.
- C. Concrete Properties:
 - 1. Compressive Strength (28 days): 3000 psi, except as noted on drawings.
 - 2. Air Content: 5% to 8% for pavement, curb and sidewalk.

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3. Slump Limit: maximum of 5 inches at time of placement, 2 inch maximum for curb and sidewalk.
 4. Maximum Aggregate Size: 1 1/2" inch.
- D. Coloring Agent: When required, add coloring agent to mix according to manufacturer's written instructions.
1. Expansion and Isolation Joint-Filler Strips: ASTM D1751, asphalt-saturated cellulosic fiber, or ASTM D1752, cork or manufactured cork; and
 2. Coloring Agent: ASTM C979/C979M, synthetic mineral-oxide pigments or colored water-reducing admixtures; color stable, nonfading, and resistant to lime and other manufactured.

2.6 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. Color to match concrete color. Submit colors to Architect for approval.
1. Cold-Applied Joint Sealant ASTM D5893, self-leveling silicone sealant; and
 2. Hot-Applied Joint Sealant: ASTM D3405, Polymeric sealant.
- C. Joint Fillers:
1. Unless otherwise noted on the drawings, use resilient pre-molded bituminous impregnated fiberboard units complying manufactured ASTM D1751, manufactured cellulosic fiber, AASHTO M 153, Type 1; or ASTM D1752, cork or manufactured cork.

2.7 MIXING

- A. On Project Site: On-site mixing must be approved by the Owner. Mix in drum type batch mixer, complying with ASTM C685/C685M. Mix each batch not less than 1-1/2 minutes and not more than 5 minutes.
- B. Transit Mixers: Comply with ASTM C94/C94M and ASTM C1116/C1116M.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify compacted subgrade is acceptable and ready to support paving and imposed loads.
- B. Verify gradients and elevations of base are correct.

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- C. Proceed with decorative concrete pavement installation only after nonconforming conditions have been corrected and subgrade is ready to receive pavement. Do not place integrally colored concrete where standing water is present.

3.2 SUBBASE

- A. Proof roll prepared subbase, per Division 31 and the geotechnical report, and remove loose material from the surface.

3.3 PREPARATION

- A. Moisten base to minimize absorption of water from fresh concrete.
- B. Notify Architect minimum 24 hours prior to commencement of concreting operations.

3.4 FORMING

- A. Place and secure forms to correct location, dimension, profile, and gradient.
 - 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 full depth of the concrete and of a strength when staked, sufficient to resist the pressure of the concrete and the loads resulting from finish operations without springing, setting or losing their shape.
- B. Place joint filler vertical in position, in straight lines. Secure to formwork during concrete placement.

3.5 REINFORCEMENT

- A. Place reinforcement as indicated.
- B. Install welded wire fabric in lengths as long as practicable; lap at least one full mesh, and lace splices with wire; and
- C. Support reinforcing steel on wire chairs to ensure that wire stays mid-depth of sidewalk section during concrete pour.

3.6 COLD AND HOT WEATHER CONCRETING

- A. Follow recommendations of ACI 305R when concreting during hot weather.

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- B. Follow recommendations of ACI 306R when concreting during cold weather.
- C. Do not place concrete when base surface temperature is less than 40 degrees F, or surface is wet or frozen.

3.7 PLACING CONCRETE

- A. Coordinate installation of snow melting components.
- B. Place concrete in accordance with ACI 304R, and as indicated on drawings.
- C. Place concrete continuously over the full width of the panel and between predetermined construction joints.
- D. Moisten subbase to provide uniform dampened condition at time concrete is placed;
- E. Consolidate concrete by mechanical vibrating equipment supplemented by hand-spading, rodding, or tamping according to recommendations in ACI 309R;
- F. Screed and initial-float concrete surfaces with darby or bull float before excess moisture or bleed water appears on the surface; and
- G. Protect concrete from cold or hot weather during mixing, placing and curing.
- H. 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. Evaporation Retarder must be suitable for use on integral colored or decorative concrete.

3.8 JOINTS

- A. 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, or as indicated on the plans. Construct transverse joints perpendicular to centerline unless otherwise detailed.
- B. Expansion and Contraction Joints: as indicated below, unless otherwise indicated on the drawings:
 - 1. Provide joint filler for the entire depth of the slab section and not less than 1 inch below finished surface so as to allow for joint sealer.
 - 2. Provide thickened edge expansion joint as indicated on the drawings.
- C. Control Joints:
 - 1. Unless otherwise indicated on the plans, depth shall be equal to 1/4 of the concrete thickness or 1 inch, whichever is deeper.

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2. For Labyrinth: spacing shall be placed per manufacturers recommendation.
3. For Sidewalks: spacing shall be placed as shown on 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.
- D. Construction Joints: place at end of placements and at locations where placement operations are stopped for period of more than 1/2 hour, except where they terminate at expansion joints. Provide 1/4 inch by 4 1/2 inch Diamond Dowels by PNA at 24 inches on center or as shown on the drawings.
- E. Isolation Joints: Locate as indicated on the drawings and at catch basin, manholes, inlets, structures, walks, light pole bases and other fixed objects.
- F. Joint Fillers: Extend joint fillers full-width and depth of joint and not less than 1/2 inch or more than 1 inch 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.
- G. Joint Sealants: seal joints with approved exterior pavement joint sealants, installed per manufacturer's recommendations.
- H. Edging: Tool edges of pavement, gutters, curbs, and joints in concrete after initial floating with an edging tool to a 1/4 inch radius. Repeat tooling of edges after applying surface finishes. eliminate tool marks on concrete surfaces.

3.9 FINISHING

- A. General: do not add water to concrete surfaces during finishing operations.
- B. Float Finish: Begin the second floating operation when bleed-water sheen has disappeared and concrete surface has stiffened sufficiently to permit operations. Float surface with power-driven floats, or by hand floating if area is small or inaccessible to power units. Finish surfaces to true planes. Cut down high spots and fill low spots. Refloat surface immediately to uniform granular texture.
- C. Broom Finish: Texture to be as noted on plans and details. Pull broom across freshly floated concrete to produce fine/medium/coarse texture in straight lines perpendicular to the main line of traffic. Do not dampen brooms.
- D. Trowel Finish: Dimension to be as noted on plans and details. Provide a smooth surface. Do not over trowel or start troweling late.
 1. Hand Trowel: Use steel trowel.

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2. Machine Trowel: Use steel trowel blades.
 3. Broom Finish: Texture to be as noted on plans and details. Pull broom across freshly floated concrete to produce fine/medium/coarse texture in straight lines perpendicular to the main line of traffic. Do not dampen brooms.
- E. Stamped: Texture to be as noted on the plans and details, and per manufacturer's instructions.
- F. Abraded Surface: Method: Abraded blast. Reveal: Projection of aggregate from mortar after completion of exposure operations to be medium, with a maximum 1/4 inch reveal.
1. For labyrinth and installations using custom stenciling, coordinate depth of abraded surface with stencil manufacturer.
- G. 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.

3.10 TOLERANCES

- A. Comply with tolerances of ACI 117 and as follows:
1. Maximum Variation of Surface Flatness: 1/4 inch in 10 ft.
 2. Thickness: Plus 3/8 inch, minus 1/4 inch.
 3. Elevation: 1/4 inch.
 4. Lateral Alignment and Spacing of Tie Bars and Dowels: 1 inch.
 5. Vertical Alignment of Tie Bars and Dowels: 1/4 inch.
 6. Alignment of Tie Bar end Relative to Line Perpendicular to Pavement Edge: 1/2 inch.
 7. Joint Spacing: 3 inches.
 8. Contraction Joint Depth: Plus 1/4 inch, no minus.
 9. Joint Width: Plus 1/8 inch, no minus.

3.11 FIELD QUALITY CONTROL

- A. Contractor shall engage and pay a qualified, independent testing agency to perform field quality control tests, as specified in Section 01 4000 - Quality Requirements.
- B. Provide free access to concrete operations at project site and cooperate with appointed firm.

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- C. Performed A slump test and air test shall be for each load delivered.
- D. Compressive Strength Tests: ASTM C39/C39M; for each test, mold and cure four concrete test cylinders. Obtain test samples for every 100 cu yd or less of each class of concrete placed. Two cylinders shall be broken at 7 days and 2 cylinders shall be broken at 28 days.
- E. Maintain records of placed concrete items. Record date, location of pour, quantity, air temperature, and test samples taken.
- F. Remove and replace decorative cement concrete pavement where test results indicate that it does not comply with specified requirements. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

3.12 REPAIRS AND PROTECTION

- A. Immediately after placement, protect pavement from premature drying, excessive hot or cold temperatures, and mechanical injury.
- 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 two days before date schedule for substantial completion inspections.
- D. Remove and replace concrete pavement that is broken, damaged, or defective or does not meet requirements of this section. Removals shall be made in complete sections from joint to joint, unless otherwise approved by the Architect

END OF SECTION

SECTION 32 1723.13 - PAINTED PAVEMENT MARKINGS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Parking lot markings, including parking bays, arrows, and accessibility symbols.
- B. Parking lot marking removals.

1.2 REFERENCE STANDARDS

- A. FS TT-P-1952 - Paint, Traffic Black, and Airfield Marking, Waterborne; Rev. E, 2007.
- B. MPI (APL) - Master Painters Institute Approved Products List; Master Painters and Decorators Association; Current Edition.
- C. FHWA MUTCD - Manual on Uniform Traffic Control Devices for Streets and Highways; U.S. Department of Transportation, Federal Highway Administration; Current Edition.

1.3 SUBMITTALS

- A. Product Data: Manufacturer's data sheets on each product to be used, including:
 - 1. Preparation instructions and recommendations.
 - 2. Storage and handling requirements and recommendations.
 - 3. Installation methods.
- B. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. Extra Paint: 2 containers, 1 gallon size, of each type and color.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Deliver paint in containers of at least 5 gallons accompanied by batch certificate.
- B. Store products in manufacturer's unopened packaging until ready for installation.
- C. Store and dispose of solvent-based materials, and materials used with solvent-based materials, in accordance with requirements of local authorities having jurisdiction.

1.5 FIELD CONDITIONS

- A. Do not install products under environmental conditions outside manufacturer's absolute limits.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Line and Zone Marking Paint: MPI (APL) No. 97 Latex Traffic Marking Paint; color(s) as indicated.
 - 1. Crosswalks: White.
 - 2. Parking Stall Striping: White.
 - 3. Accessibility Symbols: Blue and white, as noted on the drawings.
- B. Paint For Obliterating Existing Markings: FS TT-P-1952; black for bituminous pavements, gray for portland cement pavements.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Do not begin installation until substrates have been properly prepared.

3.2 PREPARATION

- A. Prepare surfaces using the methods recommended by the manufacturer for achieving the best result for the substrate under the project conditions.
- B. Obliteration of existing markings using paint is acceptable in lieu of removal; apply the black paint in as many coats as necessary to completely obliterate the existing markings.
- C. Clean surfaces thoroughly prior to installation.
 - 1. Remove dust, dirt, and other granular surface deposits by sweeping, blowing with compressed air, rinsing with water, or a combination of these methods.
 - 2. Completely remove rubber deposits, existing paint markings, and other coatings adhering to the pavement, by scraping, wire brushing, sandblasting, mechanical abrasion, or approved chemicals.
- D. Where oil or grease are present, scrub affected areas with several applications of trisodium phosphate solution or other approved detergent or degreaser, and rinse thoroughly after each application; after cleaning, seal oil-soaked areas with cut shellac to prevent bleeding through the new paint.
- E. Establish survey control points to determine locations and dimensions of markings; provide templates to control paint application by type and color at necessary intervals.

3.3 INSTALLATION

- A. Begin pavement marking as soon as practicable after surface has been cleaned and dried.
- B. Do not apply paint if temperature of surface to be painted or the atmosphere is less than 50 degrees F or more than 95 degrees F.
- C. Apply in accordance with manufacturer's instructions using an experienced technician that is thoroughly familiar with equipment, materials, and marking layouts.
- D. Comply with FHWA MUTCD manual (<http://mutcd.fhwa.dot.gov>) for details not shown.
- E. Apply markings in locations determined by measurement from survey control points; preserve control points until after markings have been accepted.
- F. Apply uniformly painted markings of color(s), lengths, and widths as indicated on drawings true, sharp edges and ends.
 - 1. Apply paint in one coat only.
 - 2. Wet Film Thickness: 0.015 inch, minimum.
 - 3. Width Tolerance: Plus or minus 1/8 inch.
- G. Parking Lots: Apply parking space lines, entrance and exit arrows, painted curbs, and other markings indicated on drawings.
 - 1. Mark the International Symbol of Accessibility at indicated parking spaces.
 - 2. Hand application by pneumatic spray is acceptable.
- H. Symbols: Use a suitable template that will provide a pavement marking with true, sharp edges and ends, of the design and size indicated.

3.4 DRYING, PROTECTION, AND REPLACEMENT

- A. Protect newly painted markings so that paint is not picked up by tires, smeared, or tracked.
- B. Provide barricades, warning signs, and flags as necessary to prevent traffic crossing newly painted markings.
- C. Allow paint to dry at least the minimum time specified by the applicable paint standard and not less than that recommended by the manufacturer.
- D. Remove and replace markings that are applied at less than minimum material rates; deviate from true alignment; exceed length and width tolerances; or show light spots, smears, or other deficiencies or irregularities.

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- E. Remove markings in manner to avoid damage to the surface to which the marking was applied, using carefully controlled sand blasting, approved grinding equipment, or other approved method.
- F. Replace removed markings at no additional cost to Owner.

END OF SECTION

SECTION 32 3119 - DECORATIVE METAL FENCES AND GATES

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Decorative steel fences.

1.2 RELATED REQUIREMENTS

- A. Section 03 3000 - Cast-in-Place Concrete.
- B. Section 31 2316 - Excavation.

1.3 REFERENCE STANDARDS

- A. ASTM A276/A276M - Standard Specification for Stainless Steel Bars and Shapes; 2017.
- B. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process; 2017.
- C. ASTM B117 - Standard Practice for Operating Salt Spray (Fog) Apparatus; 2016.
- D. ASTM D523 - Standard Test Method for Specular Gloss; 2014 (Reapproved 2018).
- E. ASTM D714 - Standard Test Method for Evaluating Degree of Blistering of Paints; 2002 (Reapproved 2017).
- F. ASTM D822/D822M - Standard Practice for Filtered Open-Flame Carbon-Arc Exposures of Paint and Related Coatings; 2013 (Reapproved 2018).
- G. ASTM D1654 - Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments; 2008, with Editorial Revision (2017).
- H. ASTM D2244 - Standard Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates; 2016.
- I. ASTM D2794 - Standard Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact); 1993 (Reapproved 2019).
- J. ASTM D3359 - Standard Test Method for Rating Adhesion by Tape Test; 2017.
- K. ASTM F2408 - Standard Specification for Ornamental Fences Employing Galvanized Steel Tubular Pickets; 2016.

1.4 ADMINISTRATIVE REQUIREMENTS

- A. Preinstallation Meeting: Conduct a preinstallation meeting one week prior to start of work of this section; require attendance by affected installers.

1.5 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Submit manufacturer's data sheets on each product to be used, including:
 - 1. Preparation instructions and recommendations.
 - 2. Storage and handling requirements and recommendations.
 - 3. Installation methods.
- C. Shop Drawings:
 - 1. Indicate plan layout, spacing of components, post foundation dimensions, hardware anchorage, gates, and schedule of components.
- D. Samples: Submit two samples of fence panels, slat infill, 6 inch by 6 inch in size illustrating construction and colored finish.
- E. Installer's Qualification Statement.
- F. Manufacturer's Warranty.

1.6 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing products specified in this section with minimum five years documented experience.
- B. Installer Qualifications: Experienced with type of construction involved and materials and techniques specified and approved by fence manufacturer.

1.7 DELIVERY, STORAGE AND HANDLING

- A. Store materials in a manner to ensure proper ventilation and drainage. Protect against damage, weather, vandalism and theft.

1.8 WARRANTY

- A. See Section 01 7800 - Closeout Submittals, for additional warranty requirements.
- B. Provide 10 year manufacturer warranty for finish.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Decorative Metal Fences and Gates:
 - 1. Omega II Fence Systems: www.omegafence.com/#sle.
 - 2. Substitutions: See Section 01 6000 - Product Requirements.

2.2 FENCES

- A. Fences: Complete factory-fabricated system of posts and panels, accessories, fittings, and fasteners; finished with electrodeposition coating, and having the following performance characteristics:
- B. Electro-Deposition Coating: Multistage pretreatment/wash with zinc phosphate, followed by epoxy primer and acrylic topcoat.
 - 1. Total Coating Thickness: 2 mils, minimum.
 - 2. Color: As shown on drawings.
 - 3. Color: As scheduled.
 - 4. Coating Performance: Comply with general requirements of ASTM F2408.
 - a. Adhesion: ASTM D3359 (Method B); Class 3B with 90 percent or more of coating remaining in tested area.
 - b. Corrosion Resistance: ASTM B117, ASTM D714 and ASTM D1654; 1/8 inch coating loss or medium No.8 blisters after 1,500 hours.
 - c. Impact Resistance: ASTM D2794; 60 inch pounds.
 - d. Weathering Resistance: ASTM D523, ASTM D822/D822M and ASTM D2244; less than 60 percent loss of gloss.
- C. Steel: ASTM A653/A653M; tensile strength 45,000 psi, minimum.
 - 1. Hot-dip galvanized; ASTM A653/A653M, G60.

2.3 STEEL MESH FENCE

- A. Provide fence meeting requirements for Industrial class as defined by ASTM F2408.
- B. Model "OMEGA CLASSIC" - Steel Mesh Fence Panels: Fusion welded; 6 feet high by 7.66 feet long.
 - 1. Panel Style: Steel rods with flats.
 - 2. Attach panels to posts with manufacturer's standard panel brackets.

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- C. Posts: Steel tube.
 - 1. Size: Per schedule.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Do not begin installation until substrates have been properly prepared.
- B. If substrate preparation is the responsibility of another installer, notify Architect of unsatisfactory preparation before proceeding.

3.2 PREPARATION

- A. Clean surfaces thoroughly prior to installation.

3.3 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Set fence posts in accordance with the manufacturer recommended spacing.

3.4 CLEANING

- A. Clean jobsite of excess materials; scatter excess material from post hole excavations uniformly away from posts. Remove excess material if required.
- B. Clean fence with mild household detergent and clean water rinse well.
- C. Remove mortar from exposed posts and other fencing material using a 10 percent solution of muriatic acid followed immediately by several rinses with clean water.
- D. Touch up scratched surfaces using materials recommended by manufacturer. Match touched-up paint color to factory-applied finish.

3.5 CLOSEOUT ACTIVITIES

- A. See Section 01 7800 - Closeout Submittals, for closeout submittals.
- B. See Section 01 7900 - Demonstration and Training, for additional requirements.
- C. Demonstrate proper operation of equipment to Owner's designated representative.

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- D. Demonstration: Demonstrate operation of system to Owner's personnel.
1. Use operation and maintenance data as reference during demonstration.
 2. Briefly describe function, operation, and maintenance of each component.

END OF SECTION

SECTION 32 3300 - SITE FURNISHINGS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Benches.
- B. Tables
- C.
- D.

1.2 RELATED REQUIREMENTS

- A. Division 05: Miscellaneous metal for metal anchors.
- B. Section 05 5000 - Metal Fabrications: Anchors to attach site furnishings to mounting surfaces.
- C. Division 32: Concrete pavement and cast-in-place concrete.

1.3 REFERENCE STANDARDS

- A. ADA Standards - Americans with Disabilities Act (ADA) Standards for Accessible Design; 2010.
- B. ASTM A36/A36M - Standard Specification for Carbon Structural Steel; 2014.
- C. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless; 2012.
- D. ASTM A500/A500M - Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes; 2013.
- E. ASTM A666 - Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar; 2015.
- F. ASTM B211/B211M - Standard Specification for Aluminum and Aluminum-Alloy Rolled or Cold Finished Bar, Rod, and Wire; 2019.

1.4 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

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- B. Product Data: Provide manufacturer's specifications and descriptive literature, installation instructions, and maintenance information.
- C. Shop Drawings: Indicate plans for each unit or group of units, elevations with model number, overall dimensions, construction, and anchorage details.

1.5 SUBSTITUTIONS

- A. See Section 01 6000 - Product Requirements for substitution procedures.

1.6 WARRANTY

- A. See Section 01 7800 - Closeout Submittals for additional warranty requirements.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Metal Furnishings:
 - 1. Forms+Surfaces: www.forms-surfaces.com/#sle.
 - 2. Substitutions: See Section 01 6000 - Product Requirements.

2.2 METAL FURNISHINGS

- A. Metal Furnishings, General:
 - 1. Steel components: Plates, bars, and shapes complying with ASTM A36/A36M and tubing complying with ASTM A500/A500M; cleaned, treated, and powder-coated.
 - 2. Aluminum Components: ASTM B211/B211M.
 - 3. Hardware: Stainless steel.
- B. Bench: Metal frame and seat section without back.
 - 1. Frame: Cast aluminum, color Argento Texture
 - 2. Seat: Extruded aluminum, color Dark Corten Texture.
 - 3. Length: 71.75 inches.
 - 4. Width: 17.75 inches.
 - 5. Height: 17.0 inches.
 - 6. Mounting: Surface.
 - 7. Products:

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- a. Forms+Surfaces Apex Bench.
- C. Waste and Recycling Receptacles: Steel frame with laser cut steel panels and rain hat.
- 1. Capacity: 60 gallons.
 - 2. Shape: Round.
 - 3. Length: 36.5 inches.
 - 4. Width: 23.1 inches.
 - 5. Height: 47.1 inches.
 - 6. Mounting: Surface with levelers.
 - 7. Color: Argento Texture rain hat and frame and Dark Corten Texture body and door.
 - 8. Basis of Design: Tonyo 60-Gallon Litter and Recycling Receptacle SLTNO-230S
 - a. Forms+Surfaces: www.forms-surfaces.com/#esl.
- D. Metal Tables:
- 1. Frame and Top: Steel.
 - 2. Seating: Compliant with ADA Standards.
 - 3. Shape: Round, 30" diameter with 24" base plate.
 - 4. Finish: Satin
 - 5. Mounting: Freestanding.
 - 6. Basis of Design: Forms+Surfaces Column Table SPCOL-T24R30
 - a. Forms+Surfaces: www.forms-surfaces.com/#sle.
- E. Metal Chairs:
- 1. Frame: Aluminum
 - 2. Slats: Aluminum
 - 3. Seating: Compliant with ADA Standards.
 - 4. Color: Dark Corten Texture
 - 5. Mounting: Freestanding
 - 6. Basis of Design: Forms+Surfaces Avivo Chair with arms and Riva perforation SCAVO-A
 - a. Forms+Surfaces: www.forms-surfaces.com/#sle

2.3 BOLLARDS

- A. Steel Pipe Bollards: Hollow steel pipe with plain shaft.
- 1. Shape: Square.
 - 2. Width: ____ inches.

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3. Height: __ inches.
4. Materials:
 - a. Steel Pipe: ASTM A53/A53M, standard weight.
 - b. Factory Finish: Primed.
5. Mounting: In-ground.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify proper installation of mounting surfaces, preinstalled anchor bolts, and other mounting devices; and ready to receive site furnishing items.
- B. Do not begin installation until unacceptable conditions are corrected.

3.2 INSTALLATION

- A. Install site furnishings in accordance with approved shop drawings, and manufacturer's installation instructions.
- B. Provide level mounting surfaces for site furnishing items.

END OF SECTION

SECTION 32 3313 - SITE BICYCLE RACKS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Exterior bicycle racks.

1.2 RELATED REQUIREMENTS

- A. Section 03 3000 - Cast-in-Place Concrete: Mounting surface for bicycle racks.
- B. Section 05 5000 - Metal Fabrications: Custom metal outdoor furnishings.

1.3 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements for submittal procedures.
- B. Product Data: Manufacturer's data sheets on each product to be used, including:
 - 1. Preparation instructions and recommendations.
 - 2. Storage and handling requirements and recommendations.
 - 3. Installation methods.
- C. Shop Drawings: Indicate size, shape, and dimensions, including clearances from adjacent walls, doors, and obstructions.
- D. Selection Samples: For each finish product specified, color chips representing manufacturer's full range of available colors and patterns.

1.4 SUBSTITUTIONS

- A. See Section 01 6000 - Product Requirements, for substitutions.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Store products in manufacturer's unopened packaging until ready for installation.
- B. Handle racks with sufficient care to prevent scratches and other damage to the finish.

1.6 WARRANTY

- A. See Section 01 7800 - Closeout Submittals.

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- B. Provide manufacturer's limited warranty against defects in materials or workmanship for a minimum period of 10 years from Date of Substantial Completion.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Exterior Bicycle Racks:
 - 1. Substitutions: See Section 01 6000 - Product Requirements.

2.2 BICYCLE RACKS

- A. Exterior Bicycle Racks: Device allows user-provided lock to simultaneously secure one wheel and part of the frame on each bicycle parked or racked.
 - 1. Basis of Design: Forms+Surfaces Twist Bike Rack SKTWS
 - 2. Style: Sculptural.
 - 3. Capacity: Two bicycles.
 - 4. Mounting, Ground: Embedded anchors.
 - 5. Finish: Powder coat, maintenance-free and weather-resistant.
 - 6. Color: Dark Corten Texture.
 - 7. Accessories: Mounting Hardware Cover Plate.
- B. Materials:
 - 1. Corrosion-resistant aluminum with powdercoat finish.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Examine surfaces to receive bicycle racks.
- B. If substrate preparation is the responsibility of another installer, notify Architect of unsatisfactory conditions before proceeding.
- C. Do not begin installation until unsatisfactory conditions are corrected.

3.2 PREPARATION

- A. Ensure surfaces to receive bicycle racks are clean, flat, and level.

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3.3 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install level, plumb, square, and correctly located as indicated on drawings.

3.4 CLEANING

- A. Clean installed work to like-new condition. Do not use cleaning materials or methods that could damage finish.

3.5 PROTECTION

- A. Protect installed products until completion of project.
- B. Touch-up, repair or replace damaged products before Date of Substantial Completion.

END OF SECTION

SECTION 32 8423 - IRRIGATION SYSTEM

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Pipe and fittings, valves, sprinkler heads, emitters, and accessories.
- B. Control system.
- C. System design and construction.

1.2 RELATED REQUIREMENTS

- A. Section 01 3000 - Administrative Requirements: Submittal Procedures.
- B. Section 01 6000 - Product Requirements
- C. Section 01 7000 - Execution and Closeout Requirements.
- D. Section 26 0519 - Low-Voltage Electrical Power Conductors and Cables.
- E. Section 31 2316.13 - Trenching: Excavating and backfilling for irrigation piping.
- F. Section 32 9300 - Plants.

1.3 REFERENCE STANDARDS

- A. ASTM D1784 - Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds; 2011.
- B. ASTM D2241 - Standard Specification for Poly (Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series); 2015.
- C. ASTM D2564 - Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems; 2012.
- D. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2014.

1.4 ADMINISTRATIVE REQUIREMENTS

- A. Coordination: Coordinate the construction of the irrigation system with related work.
 - 1. Retrofit work to provide irrigation to existing plant material to remain shall be completed at the beginning of demolition.

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2. Irrigation point of connection shall be verified and or installed and tested by the Contractor prior to any irrigation system construction.
 3. Sleeving shall occur in coordination with hardscape construction.
 4. As-built or "Record" documentation and testing shall occur prior to final grading.
 5. All irrigation shall be installed, documented, tested and fully functional prior to any landscape materials installation.
- B. Coordination: Coordinate the work with site backfilling, landscape grading and delivery of plant life.
- C. Preinstallation Meeting: Convene one week prior to commencing work of this section.
- D. Instructional Training: The contractor shall provide a four (4) hour (minimum) on-site irrigation system instructional training session to Owner's representatives prior to substantial completion. Subjects to be covered shall include winterization and spring start-up procedures (Toro Tech Tip Bulletin #2009-01), sprinkler disassembly, adjustment and repair, controller operation and troubleshooting, grounding system maintenance, backflow preventer maintenance, and any other topics pertinent to the system.

1.5 SUBMITTALS

- A. Product Data: Provide data on system components including the control system and wiring diagrams.
- B. Qualification Data for Irrigation Installer:
1. Submit license, personnel, insurance and equipment information to illustrate that Irrigation installer is capable of and legally qualified to perform the type and scale of work required.
- C. Construction Schedule: indicating when the pre-installation conference will occur and how irrigation retrofit and new construction activities, including testing, will fit into the overall project construction schedule and sequencing, including warranty periods.
- D. Testing Data: Irrigation point of connection test results.
- E. Results of dynamic water pressure test.
- F. Certificate: Certify that products of this section approved by authority having jurisdiction.

1.6 AS-BUILT RECORDS

- A. Submit an accurate plan of the installed irrigation system, including the actual locations of all concealed and visible components and submit prior to substantial completion.
- B. Record Drawings/Documents shall:

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1. Provide a clean, accurate and professional as-built record drawing. Include color-coded zone valve as-builts that indicate the area of planting served.
 2. Draft onto a clean, scaled base of the original plan.
 3. Indicate the components and locations of installed materials.
 4. Include a detailed legend and detailed notes indicating special features and dimensions, and important component instructions.
- C. Provide color hard copy and digital images of the document (pdf format) to the Architect.
- D. Provide two 11" by 17" laminated waterproof controller sheets, and place one in the controller and give one to the Owner.
- E. Operation and Maintenance Data:
1. Provide instructions for operation and maintenance of system and controls, seasonal activation and shutdown, and manufacturer's parts catalog.
 2. Provide schedule indicating length of time each valve is required to be open to provide a determined amount of water.
- F. Maintenance Materials: Provide the following for Owner's use in maintenance of project.
1. See Section 01 6000 - Product Requirements, for additional provisions.
 2. Extra Drip Emitter: 25 of each type and size.
 3. Extra Valve Keys for Manual Valves: Two.
 4. Extra Valve Box Keys: Two.
 5. Extra Valve Marker Keys: Two.
 6. Wrenches: One for each type head core and for removing and installing each type of head.

1.7 SUBSTITUTIONS

- A. See Section 01 6000 - Product Requirements for substitution procedures.

1.8 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing products specified in this section, with not less than three years of documented experience.
- B. Installer Qualifications: Company specializing in performing the work of this section with minimum five years of experience.
- C. Irrigation System Documents:

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1. Have on site, at all work times, all construction documents related to the installation of the irrigation system including plan, detail drawings, specifications, addenda and change orders.

1.9 REGULATORY REQUIREMENTS

- A. Conform to applicable code for piping and component requirements.
- B. Provide certificate of compliance from authority having jurisdiction indicating approval of products in system.

1.10 TESTING

- A. Coordinate testing and inspections with the Architect.
- B. Give a minimum of 48 hours written notice to the Architect prior to inspection and testing.
- C. Do not proceed with work following inspections or testing, without written notice to proceed from the Architect.

1.11 HANDLING, STORAGE AND PROTECTION

- A. Load, unload and store materials in accordance with the manufacturer's recommendations.
- B. Deliver pipe in unbroken bundles, packaged to provide adequate protection. Reject pipe dropped in the unloading process and removed from the site.
- C. Cover PVC pipe and fittings to protect it from direct sunlight to prevent discoloration and sunburning. Sunburned or discolored pipe shall be rejected.
- D. PVC pipe shall be transported in a vehicle with a bed long enough to allow the pipe to lie flat without subjecting it to undue bending or concentrated external loads at any point. Any section of pipe that has been dented or damaged or in any way found to be defective, either before or after installation, shall be replaced.

1.12 WARRANTY

- A. See Section 01 7000 - Execution and Closeout Requirements.
- B. Substantial or final completion inspection
 1. The Contractor shall coordinate with the Architect an inspection of the completed or substantially completed irrigation system. Substantially completed means that all parts and components of the irrigation system are installed, functional and undamaged. All emitters shall be adjusted, the backflow device shall have been tested and accepted and the irrigation controller is installed and functioning. The Contractor shall have a complete

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- “red-line” as-built record drawing of the installed irrigation system noting any and all changes or deviations from that of the original design.
- a. The Contractor shall demonstrate the operation of each zone valve and provide a walk-through to demonstrate the functionality of each irrigated section.
 - b. The Contractor shall demonstrate that all valve box interiors are dry and free from leaks or drips.
 - c. The Contractor shall provide a copy of the “red-line” irrigation as-built Record Drawing to the A/E for inspection and verification.
2. A final observation report shall be generated and available to the Contractor within a reasonable time period. The inspection report may include “punch-list” items that the Contractor shall address in order to receive final acceptance. The Contractor shall include a copy of the substantial or final completion observation record in the “Operations and Maintenance Manual”.
- C. In addition to manufacturer’s guarantee and warranties, the Contractor shall guarantee his work for a period of one (1) year from the date of substantial completion. The Contractor, as his own expense, shall repair or replace all defective work, materials, leaks, trench settlement and any other work performed by the Contractor under this contract. The Contractor shall also keep sprinkler heads, bubblers, valves, and valve boxes in adjustment and at the proper level and grade for the duration of the warranty period
1. Should operational difficulties in connection with the irrigation system develop within the specified guarantee period, said difficulties shall be corrected within a reasonable length of time depending upon the magnitude of the problem.
 2. Warranty shall cover repair of damage to any part of the premises resulting from leaks or other defects in materials, equipment or workmanship, to the satisfaction of and at no expense to the Owner.
 3. Materials shall have a minimum guarantee against defects for a period of one (1) year from date of acceptance. Some products may have extended manufacturer warranties, which shall apply to the end user.
 4. During the one year warranty period, if the amount of system leaks or breaks exceeds (five), the Contractor shall extend the warranty period an additional one year. Leaks and breaks shall be documented in writing by the Owner and Contractor
- D. Emergency Repairs: If the Contractor does not respond to the Owner’s request for repair work within 24 hours, the Owner may proceed with the necessary repairs and charge the Contractor for all expenses incurred in the repair work. These repairs will not relieve the Contractor of any part of his guarantee obligation.
- E. System Adjustments: Upon completion of the installation, the Contractor shall adjust system components and controller to provide optimum sprinkler system performance including nozzle changes, adjustments to arc and radius of throw. The Owner will be responsible for minor adjustments to the system during the guarantee period.
- F. Service Organizations: Provide the Owner with the names and addresses of permanent service organizations trained by the equipment manufacturers capable of providing satisfactory service within 24 hours.

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- G. If trench, sprinkler or valve box settlement of ½” or more occurs within one (1) year from final acceptance, remove the sod or finish grade treatment and refill and re-compact the soil structure. Reinstall sod or finish grade treatment material to the satisfaction of the Owner.

PART 2 PRODUCTS

2.1 REGULATORY REQUIREMENTS

- A. Comply with applicable code for piping and component requirements.
- B. Provide certificate of compliance from authority having jurisdiction indicating approval of products in system.

2.2 IRRIGATION SYSTEM

- A. Electric solenoid controlled retrofitted and new underground irrigation system, with low point self drain.
 - 1. Source Power: 120 volt, 1.9 A., single phase.
- B. Manufacturers:
 - 1. Basis of design: as existing and as noted on plans.
 - 2. Substitutions: See Section 01 6000 - Product Requirements.

2.3 PIPE MATERIALS

- A. Schedule 40 Solvent Weld -Lateral / Mainline Piping - Sizes 3 inches and Smaller: Virgin polyvinyl chloride with integral solvent weld bells in accordance with ASTM D2241 and ASTM D1784, cell classification 12454-B type 1, grade 1.
- B. Fittings: Type and style of connection to match pipe.
- C. Pipe Risers at Valves: 160 psi PVC pipe.
- D. Drip Tubing: 3/4 inch polyethylene, commercial grade, pressure rated to a minimum of 45 psi. May require stripes or markings for identification (refer to plan).
- E. Solvent Cement: ASTM D2564 for PVC pipe and fittings.
- F. Solder and Flux: ASTM B32 solder, with suitable flux.
- G. Sleeve Material: PVC.

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2.4 OUTLETS

- A. Drip emitters: Type, model, size and manufacturer as specified on drawings or approved equal.

2.5 VALVES

- A. Valves, air release valves, pressure regulating valves, master valves, gate valves, drain valves, etc. shall be of the type, model, size and manufacturer as specified on the drawings or approved equal.

- B. Valve Boxes:

1. Large Valve Box(es): 1324-12 and 1324-15
 - a. HDPE plastic body, 15 3/4 x 25 1/4 inches top access size, 24 1/2" x 34" bottom size (2 boxes may be required for each component refer to detail drawing). The lid (for one box only) shall be HDPE plastic, T-style, bolt down cover .
 - 1) Applied Engineering Products: www.aepvalvebox.com.
 - 2) Oldcastle Infrastructure, Inc.; Carson: www.oldcastleinfrastructure.com.
 - 3) Approved Equal
2. Medium Valve Box: 1419-18
 - a. HDPE plastic body, 15 1/4" x 10 1/8" top access size, 19" x 13 7/8" bottom size. The lid shall be HDPE plastic, T-style, bolt down cover.
 - 1) Applied Engineering Products: www.aepvalvebox.com.
 - 2) Oldcastle Infrastructure, Inc.; Carson: www.oldcastleinfrastructure.com.
 - 3) Approved Equal
3. Small Valve Box: 910
 - a. HDPE plastic body, 10" round access with T-style, bolt down cover.
 - 1) Applied Engineering Products: www.aepvalvebox.com.
 - 2) Oldcastle Infrastructure, Inc.; Carson: www.oldcastleinfrastructure.com.
 - 3) Approved Equal
4. Cover Colors: green for use in turf areas; tan for use in rock mulch areas; or as noted on the drawings.

- C. Backflow Preventers shall be of the type, model, size and manufacturer as specified on the drawings or approved equal.

2.6 CONTROLS

- A. Controller: As noted on plans..
- B. Valves: Hydraulic; normally open; hydraulic tubing, including required fittings and accessories.

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- C. Wire Conductors: Color coded.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify location of existing irrigation system components and site utilities.
 - 1. Irrigation point of connection: For existing water source – Field locate existing piping, positively identify source, verify line size and type. Locate shut-off valves and confirm water shutdown before cutting into existing piping. Proceed with installation of tap or connection (and new shut-off valve if shown on plan). Ensure no leakage from new connection. Proceed with testing.
 - 2. Irrigation point of connection testing: Prior to any irrigation related construction, the Contractor shall verify and test the irrigation system point of connection.
 - a. Install a properly sized test assembly consisting of a connection fitting, water pressure gauge, flow meter and shutoff valve to downstream side of point of connection. The test assembly should allow the Contractor to measure the dynamic water pressure at a particular gallon-per-minute flow and have the ability to shut-off water flow.
 - b. The Contractor shall provide or construct an appropriate drainage area sized to accommodate the volume of water necessary and required for proper testing without discharging into public right-of-way or onto adjacent private property.
 - c. Initiate a water flow equal to the highest gallon-per-minute flow demand of the irrigation system as indicated on the drawings. Record the dynamic water pressure reading at the highest system flow demand. Shut off test assembly valve. Record static water pressure at zero flow. Document all recordings and test assembly make-up with digital photographs.
 - d. Report findings in writing to the Architect. The report should indicate the dynamic water pressure at the highest system flow and the static water pressure at zero flow. The report shall also include a photograph of the test assembly and a photograph for each gauge reading.
 - e. The Architect shall issue a written notice to proceed upon acceptable test results or issue further instructions upon unexpected results. Do not install any part of the irrigation system without written notice to proceed.
 - 3. Verify that required utilities are available, in proper location, and ready for use.

3.2 PREPARATION

- A. Piping layout indicated is diagrammatic only. Route piping to avoid plants, ground cover, and structures.
- B. Layout and stake locations of retrofit and new system components.

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1. Contractor to locate and mark all underground utilities, public and private, recorded and unrecorded, prior to staking.
 - a. The Contractor shall perform the field staking of these components and shall have the Architect approve locations prior to installation.
 - 1) Mainline piping
 - 2) Lateral piping
 - 3) Valves - automatic, manual, air release, pressure regulating, drain, backflow
 - 4) Controllers / Satellites
 - b. Stake all components using painted wooden stakes, flagging and or ground paint, color coordinated to the type of irrigation component.
- C. Review layout requirements with construction sequencing and other affected work, including demolition. Irrigation system retrofitting to ensure that irrigation remains operational to existing plant material to remain is to be completed at the beginning of demolition.

3.3 TRENCHING

- A. Trench in accordance with project Earthwork requirements and as noted on the drawings.
- B. Trench to accommodate grade changes and slope to drains.
- C. Maintain trenches free of debris, material, or obstructions that may damage pipe.

3.4 INSTALLATION

- A. Retrofit irrigation system to ensure that existing plant materials to remain receive irrigation throughout construction.
- B. Connect to utilities.
- C. Set outlets and box covers at finish grade elevations.
- D. Provide for thermal movement of components in system.
- E. Use threaded nipples for risers to each outlet.
- F. Install control wiring in accordance with Section 26 0519. Provide 10 inch expansion coil at each valve to which controls are connected, and at 100 ft intervals. Bury conduit beside pipe.
- G. After piping is installed, but before outlets are installed and backfilling commences, open valves and flush system with full head of water.
- H. Point of connection installation:
 1. Point of connection: Install the water source as per the instructions on the construction documents and as per the manufacturer's recommendations and instructions.

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- a. Existing Water Source: At the approximate location as indicated on the drawing, the Contractor shall locate the piping stubbed out for irrigation use. Positively identify, install shut-off valve if none exists, connect to and pipe to backflow prevention device as illustrated on plan.
2. Backflow Preventer:
 - a. Install according to the Uniform Plumbing Code, the NEC and the drawings. Protect backflow preventer from freezing with suitable heated enclosure and by draining and blowing out with compressed air before freezing weather. Provide a properly sized and installed 120V power circuit with plug-in electrical outlet for the backflow preventer heater. The 120-volt power circuit shall be sized and installed by a licensed electrician.
 - b. Provide Certified Backflow Test Certificate indicating a passing inspection, by a certified backflow technician prior to placing in service or connecting to irrigation mainline. This certificate shall be presented to the owner and the Contractor shall place a copy of this certificate in the "Operations and Maintenance Manual".
3. Test port installation (for hydrostatic pressure test):
 - a. The Contractor shall provide and install a testing port accessible to the irrigation observer, for the purposes of hydrostatic pressure testing. The test port shall consist of a direct connection into the mainline piping structure and shall provide a shut-off valve and a 1/4" FIPT connection point. The Contractor shall use an already installed service tee or termination point for the mainline connection. The Contractor shall remove the test port make-up components upon successful completion of the hydrostatic testing.

3.5 PIPING SYSTEM INSTALLATION

- A. General:
 1. Adverse trenching conditions: No additional costs will be paid if the Contractor encounters any adverse trenching conditions.
 2. Depth of Bury - Cover of Earth Over Top of Pipe: See irrigation system drawings.
- B. Backfilling and Compaction:
 1. Requirement of "OPEN TRENCH" observation:
 - a. Notify Architect a minimum of 48 hours prior to backfilling operations.
 - b. Do not backfill main line, point of connection and components including backflow preventer, gate valve, master valve and zone valve manifold until they have been observed by the Architect and Owner.
 - c. Do not backfill lateral lines until all fittings and components have been observed by Architect and Owner.
 2. Upon completion of a particular section of the irrigation system the Contractor may begin partial backfilling (center loading and thrust blocking of the piping structure). Leave all joints, risers and connections exposed for visual inspection during the hydrostatic testing. Only upon successful completion of the hydrostatic test can the backfill operation be

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completed for any one particular section. It shall be the responsibility of the Contractor to locate any leaks in the piping structure that cause unsuccessful hydrostatic test results, whether or not it is buried.

3. Backfill around pipe and 6" above pipe cannot contain rocks or stones larger than 1/2". Backfill from 6" above pipe to finish grade cannot contain any rocks or stones larger than 2". If the excavated trench material contains rocks exceeding 1/2", screen backfill to comply with criteria above. Remove unsuitable material from the site and dispose of properly.
4. In rocky areas, trench depth shall be six inches below the normal trench depth to allow for six inches of suitable backfill as padding for the pipe. Provide a minimum of six inches of padding on either side of the pipe as a buffer against the rock wall of the trench.
5. Place backfill in horizontal layers not exceeding six inches in depth; thoroughly tamp and compact with manual or mechanical compaction equipment to a minimum 95% standard proctor density. Place to original ground level or limits designated on the drawings. If settlement of trenches occurs within one year from date of completion, refill trenches and sod repaired areas.

C. PVC Pipe Installation:

1. Before installation, clean inside of the pipe of dirt and foreign matter and keep in a cleaned condition during and after installation of the pipe. Seal open ends of pipe and fittings so that trench water, earth, or foreign substances will not enter the pipe or fittings. Where pipe ends are left for future expansion or connections, valve and cap as indicated on the drawings.
2. The full length of each section of the pipe shall rest solidly upon the pipe bed, with recesses excavated to accommodate bells, joints, and couplings. Do not lay pipe in water or when trench or weather conditions are unsuitable for the work. Remove water to keep the bottom of the trench or excavation free and clear of water during the progress of the work. Pipe shall not be laid if the temperature is 32F or below. Install pipe to provide for expansion and contraction as recommended by the manufacturer.
3. The minimum horizontal clearance between lines in the same trench shall be four inches (4"). Pipe shall be installed in a straight line with changes in direction made with elbows and tees. If manual drains are installed in the system, install piping to insure a positive slope to the drain so that all water can be drained from that part of the system.
4. If curving of the pipe is necessary due to particular angles and site conditions notify the Architect and receive written authorization prior to installing. If unauthorized or unwarranted bending of the pipe is discovered, retrench and reinstall the piping as directed for any particular section or length at no additional cost to the Owner.
5. To accommodate repairs that may occur in the future, bending or curving of the pipe beyond the recommended limits of the manufacturer will not be permitted.

D. Joint Restraints and Concrete Thrust Block Installation:

1. When using ductile iron gasketed fittings, Install joint restraint systems at mainline tees, elbows and caps, also at pipe to fitting or valve to fitting connections. Restrain valves to fittings, restrain pipe to valves and restrain piping installed directly into a mainline fitting. The installation of restraints does not negate the need for concrete thrust blocking.

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2. Concrete thrust block installation:
 - a. Construct thrust blocks at mainline fitting direction changes, such as tees, elbows, reducers, caps, unrestrained isolation valves, terminations or at any other points of the system that will result in an unbalanced thrust line.
 - b. Cut a properly sized concrete form around the fitting in the undisturbed native soil. Do not form the concrete thrust block in uncompacted backfill material.
 - c. Wrap the fitting and pipe in 6-mil poly plastic sheeting and secure so that concrete does not directly contact the fitting or piping.
 - d. Pour properly mixed 3000psi concrete into the undisturbed, native soil form and allow for proper curing.
 - e. Thrust blocks shall be neatly formed, with minimal over pour and shall be level and smoothed on the exposed surface. Do not obstruct any outlets intended for future connections.

E. Sleeve Pipe - Hardscape Crossings:

1. Per Owner requirements, sleeving of irrigation lateral piping under pavement is not permitted. Provide sleeving of lateral lines through foundation walls only.
 - a. All irrigation mainline piping is to be sleeved under pavement.
2. New Construction:
 - a. Unless otherwise noted, sleeve all hardscape crossings in the early stages of construction rather than installing the pipe after the hardscape is in place.
 - b. Provide sleeve pipe two sizes larger than the pipe to be sleeved. Sleeve pipe up to 4" shall be Schedule 40 PVC solvent weld. Sleeve pipe 6" and larger shall be Class 200 PVC gasket end.
 - c. 24 volt wire shall be installed in a separate 2" Schedule 40 PVC sleeve unless noted otherwise on the drawings.
 - d. Install the piping and wire in separate sleeves.
3. Existing Concrete or Asphalt with crossing greater than six feet (6') in width:
 - a. All sleeve crossings shall be made by means of mechanized directional boring. The Contractor may elect to bore each sleeve pipe separately or use one large bore with sleeve to install more than one sleeve pipe or conduit.
 - b. The bore shall be done at the appropriate depth of bury for the particular utility (lateral, mainline or electrical) or at the deepest depth of bury if multiple utilities will be installed in the same bore sleeve.
 - c. Locate and mark all existing utilities prior to boring.
 - d. No type of water-jet bore methods may be used.
4. Existing Concrete or Asphalt with crossing less than six feet (6') in width:
 - a. The Contractor shall use a mechanical drill bore or impact bore only. The Contractor shall not use any type of water-jet bore method.
5. Alternative sleeve crossing method - by Architect approval only:

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- a. With approval from the Architect only, the Contractor may saw cut the existing concrete or asphalt, excavate sleeve trench, install sleeve, backfill, compact and patch concrete or asphalt.
- b. The saw cut(s) shall be clean and straight. The Contractor shall properly dispose of the removed material.
- c. The patch shall be configured of the same material, and be of the same color, texture and finish as the existing material.
- d. Sleeve length past hardscape edges - The ends of each sleeve pipe shall extend or be trimmed to 6" past the edge of concrete or asphalt unless otherwise directed by the A/E.

F. Flushing:

1. Thoroughly and completely flush all debris from all piping:
 - a. After installing system piping and the trenches are partially backfilled, the piping system shall be flushed at full water pressure volume. Do not install automatic valves, air release valves, pressure regulation valves, quick coupler valves, sprinklers, bubblers or drip emitters until after all piping has been thoroughly flushed and tested.
 - b. If water pressure without the emission devices installed is not sufficient to provide adequate water flow from end risers, cap off enough risers closest to the water source to provide adequate flushing of the end riser assemblies.
 - c. After the system is thoroughly flushed, risers shall be capped water-tight, and the system pressure tested in accordance with the testing section of these specifications.
 - d. At the successful conclusion of the pressure test, install valves and emission devices and complete the backfill process.
 - e. No flushing will be allowed through any emission device or valve other than isolation (gate or straight or ball). Any component other than isolation showing evidence of flushed debris shall be rejected and replaced at the Contractor's expense.

3.6 DRIP EMITTER INSTALLATION

A. General:

1. Drip emitters shall be of the manufacturer and model number specified on the drawings or approved equal, installed to grade, level and plumb in all directions unless installed on sloping terrain.
2. System piping shall be flushed thoroughly before the sprinkler heads are installed. No flushing will be allowed through the sprinkler heads.

B. Drip Emitters:

1. Drip emitters shall be installed on 1/4" polyethylene "spaghetti" tubing connected to 3/4" polyethylene drip tubing or to the particular emission device as specified on the drawings. The connection of the 1/4" tubing to the 3/4" tubing shall be made with a 1/4" barbed insert connector. Using a hole-punch tool, pierce the 3/4" tubing on the side, so that the 1/4"

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barbed connector is installed horizontally (parallel with ground). Insert one end of the barbed connector into the 3/4" tubing and ensure it is secure.

- a. Always install drip emitters at the "plant end" of the tube.
2. Insert the 1/4" tubing over the other exposed end of the barbed connector and insure it is secure. The length of 1/4" tubing shall not exceed ten feet (10') in length and shall not have multiple drip emitters installed. One drip emitter per run of 1/4" tube.
3. If plant material is installed on a slope, install drip emitters around the high end of the rootball.
4. For trees: Install drip emitters in an equal spacing pattern around the dripline of the tree. Refer to drawings for number of emitters per tree.
5. For shrubs: Install drip emitters at the dripline of shrub in an equal spacing pattern. Refer to drawings for number of emitters per shrub.
6. Each drip emitter shall be installed 1/2" below the surface of the mulch material, so that it is not exposed, but the wetting pattern is evident. The 1/4" tubing shall be secured using landscape staples in 2' intervals.
7. All tubing shall be installed to a depth of 4" unless otherwise indicated on drawings.

3.7 FIELD QUALITY CONTROL

- A. Prior to irrigation related construction, confirm the location and condition of the existing irrigation system and verify and test the irrigation system point of connection.
 1. The test assembly should allow the Contractor to measure the dynamic water pressure at a particular gallon-per-minute flow and have the ability to shut off water flow.
 2. Water from the test cannot discharge into a public right-of-way or adjacent property without written permission from the Owner.
 3. Initiate dynamic water flow equal to the highest gallon-per-minute flow demand of the irrigation system. Record the dynamic water pressure reading at the highest system flow demand. Record static water pressure at zero flow. Document all recordings and test assembly make-up with digital photographs.
 4. Submit point of connection test results in a report to the Architect. Report shall include date and time of testing, results, and photographs.
- B. Staking: locate and mark (paint or flag) portions of the irrigation system for visual inspection by the Architect.
- C. Hydrostatic Mainline Pressure Test:
 1. Conduct a hydro-static pressure test to be observed by the Architect or with prior approval, photo-video documented by the Contractor.
 2. Pre-pressurize the mainline piping to approximately 90 psi.
 3. Record the digital pressure to the 1/4" FIPT connection (with isolation valve provided by the Contractor).

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4. Document the pre-pressurized static water pressure.
 5. Pressurize the mainline piping to a full 100 psi test start pressure.
 6. Document the 100 psi pressure and then isolate the pressurizing device from the mainline piping structure.
 7. Document (with photographs with proof of day and time) the digital pressure gauge readings of the static pressure over a period of one hour and provide this to the Architect for review.
 8. A successful hydrostatic pressure test will have a recorded water pressure drop of less than or equal to 3.0 psi.
 9. If the hydrostatic pressure test is not successful, the contractor shall make the necessary repairs and schedule a new water pressure test.
- D. Prior to backfilling, test system for leakage at main piping to maintain 100 psi pressure for one hour. Leakage testing shall occur at all phased construction including initial retrofitting to ensure that existing plant material to remain receive water during construction.
- E. System is acceptable if no leakage or loss of pressure occurs and system self drains during test period.

3.8 BACKFILLING

- A. Provide 3 inch sand cover over piping.
- B. Backfill trench and compact to specified subgrade elevation. Protect piping from displacement.

3.9 SYSTEM STARTUP

- A. Prepare and start system in accordance with manufacturer's instructions.
- B. Adjust control system to achieve time cycles required.
- C. Adjust head types for full water coverage as directed.

3.10 CLOSEOUT ACTIVITIES

- A. Instruct Owner's personnel in operation and maintenance of system, including adjusting of sprinkler heads. Use operation and maintenance data as basis for demonstration.

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3.11 MAINTENANCE

- A. Provide one complete spring start-up and a fall shutdown by installer, at no extra cost to Owner.

END OF SECTION

SECTION 32 9300 - PLANTS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Preparation of subsoil.
- B. Preparation of planting backfill mixture.
- C. New trees, plants, and ground cover.
- D. Mulch and Fertilizer.
- E. Maintenance.
- F. Tree Pruning.

1.2 RELATED REQUIREMENTS

- A. Section 01 3000 - Administrative Requirements.
- B. Section 015639 - Operation and Maintenance Data.
- C. Section 01 6000 - Product Requirements.
- D. Section 01 7000 - Execution and Closeout Requirements.
- E. Section 02 4100 - Demolition.
- F. Division 31 specifications for for grading and earthwork, including subsoil and planting backfill preparation for work of this section.
- G. Section 32 8423 - Irrigation System.

1.3 DEFINITIONS

- A. Weeds: Any plant life not specified or scheduled.
- B. Plants: Living trees, plants, and ground cover specified in this Section, and described in ANSI Z60.1.

1.4 REFERENCE STANDARDS

- A. ANSI/ANLA Z60.1 - American National Standard for Nursery Stock; 2004.

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- B. ANSI A300 - American National Standard for Tree Care Operations - Tree, Shrub and Other Wood Plant Maintenance - Standard Practices.
- C. 2016 San Francisco Reduced-Risk Pesticide List.

1.5 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Qualification Data for Landscape Installer:
 - 1. Submit license, personnel, insurance and equipment information to illustrate that Landscape Installer is capable of and legally qualified to perform the type and scale of work required.
 - 2. Submit a list of similar projects completed by Landscape Installer demonstrating capabilities and experience. Include project names, addresses and year completed and include names and addresses of project contacts.
- C. Construction Schedule: indicating when the pre-installation conference will occur and how planting activities such as plant salvage, transplant and installation fit into the overall project construction schedule and sequencing, including maintenance and warranty periods.
- D. Product Data:
 - 1. Type and source of pesticides, herbicides, and fertilizers. Include project label and manufacturer's application instructions specific to this project.
 - 2. Type, source and composition of soil and soil amendments.
 - 3. Type, source and composition of weed barrier.
 - 4. Type and source of staking materials.
 - 5. List of plants including genus, species, variety, size, quantity and source.
- E. Product Samples:
 - 1. Mulch:
 - a. Submit in sealed plastic bags labeled with composition of materials by percentage weight and source of mulch. Each sample shall be typical of the lot of material to be furnished and provide an accurate representation of color, texture, and makeup.
 - b. Organic Mulch: one quart volume sample of each mulch type.
 - c. Mineral Mulch: one quart volume sample of each mulch type.
 - 2. Weed control barrier fabric.
 - 3. Compost and soil amendments: one quart volume sample of each type.
 - 4. Replacement soil mixture: one quart volume sample.
- F. Soil Testing, Results and Recommendations:

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1. Following award of the project, Contractor shall make recommendations for fertilizer and soil amendments for planting areas based on soil samples and testing by a regional laboratory during construction and prior to planting. Cost of testing is the responsibility of the Contractor.
2. Contractor shall submit results of soil tests for the landscaping indicated on the drawings to the Architect, and include the Contractor's recommendations for any changes to the specified fertilizer and soil amendment materials and ratios/rates.

G. Maintenance Data:

1. Two copies of recommended landscape operations and maintenance procedures to be followed by the Owner for one full year. Submit prior to expiration of required maintenance period.
2. Include maintenance instructions related to weed control, irrigation, fertilization, soil amendments, pest control and erosion control.

H. Record Drawings:

1. At final acceptance, Contractor shall furnish Record Drawings prepared by a qualified draftsman showing the entire completed planting area. This is the responsibility of the Contractor and is not the responsibility of others.

1.6 SUBSTITUTION

- A. See Section 01 6000 - Product Requirements, for submittal procedures.

1.7 QUALITY ASSURANCE

- A. Nursery Qualifications: Company specializing in growing and cultivating the plants with three years documented experience.
- B. Installer Qualifications: Company specializing in installing and planting the plants with five years experience.
- C. Installer Field Supervision: Installer is required to maintain an experienced full-time supervisor on the project site when work is in session. Full-time supervisor must have a current copy of construction documents for the project on-site for reference at all times.
- D. Tree Pruner Qualifications: Company specializing in pruning trees with proof of Arborist Certification.
- E. Tree Pruning: Comply with ANSI A300 Part 1.
- F. Maintenance Services: Performed by installer.
- G. Plant Material Observation: Architect may observe plant material via photos submitted by the Contractor, at place of growth or at site before installation for compliance with requirements for genus, species, variety, cultivar, size, condition of roots balls and root systems, pest, disease

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symptoms, and general quality. Architect retains the right to observe plant material at any time during construction, and to reject unsatisfactory or defective material. Contractor will remove rejected plant material immediately from the project site.

- H. Pre-installation Conference: conduct pre-installation conference at project site prior to planting operations.

1.8 REGULATORY REQUIREMENTS

- A. Comply with regulatory agencies for fertilizer and herbicide composition.
- B. Provide certificate of compliance from authority having jurisdiction indicating approval of plants, fertilizer and herbicide mixture.
- C. Plant Materials: Certified by federal department of agriculture; free of disease or hazardous insects.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Deliver fertilizer in waterproof bags showing weight, chemical analysis, and name of manufacturer.
- B. Do not prune trees and shrubs before delivery.
- C. Protect and maintain plant life until planted.
- D. Deliver plant life materials immediately prior to placement. Keep plants moist.
- E. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
- F. Provide erosion control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems or walkways.

1.10 FIELD CONDITIONS

- A. Verify actual grade elevations, service and utility locations, irrigation system components, and dimensions of planting and construction contiguous with new plantings by field measurements before proceeding with planting work.
- B. Do not interrupt services or utilities to facilities occupied by Owner or others unless permitted to do so by the Owner and Architect. Do not proceed with interruption of services or utilities without Architect's written permission. Contractor shall notify the Architect no fewer than two days in advance of proposed interruption of each services or utility.

1.11 SCHEDULING AND SEQUENCING

- A. Planting Restrictions:
 - 1. Do not install plant life when ambient temperatures may drop below 35 degrees F (2 degrees C) or rise above 90 degrees F (32 degrees C).
 - 2. Do not install plant life when wind velocity exceeds 30 mph.
- B. Weather Limitations: Perform planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions and warranty requirements.
- C. Sequencing:
 - 1. Schedule to plant after finish grades are established, irrigation is installed, and before mulching operations.

1.12 REVIEWS

- A. Coordination between Contractor and Architect for reviews and observations shall be initiated by the Contractor 48 hours in advance. Review requirement may be covered with dated photography of before, during and after conditions delivered to the architect within 24 hours of the work being completed. Use of the photography review process requires prior approval of the Architect.
- B. Required reviews include:
 - 1. Subgrade condition,
 - 2. Amended and fine graded condition at finished grades,
 - 3. Conditions during installation, and
 - 4. Conditions following installation and mulch installation.
- C. Rejected materials shall be removed immediately from the site. Expense for replacing substandard materials shall be borne by Contractor.
- D. Contractor shall not proceed with work of the next sequence without completing previous work.

1.13 PROJECT CLOSEOUT

- A. See Section 01 7000 - Execution and Closeout Requirements.
- B. Substantial completion shall be issued when the Contractor has substantially completed the work in the contract, and the Architect is satisfied with the work.

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C. Maintenance:

1. The Contractor shall maintain the planted areas regularly throughout the installation and maintenance period of 90 days following substantial completion.
2. Owner shall provide maintenance afterwards, per the recommendations outlined in the maintenance manual.
3. See Part 3 of this specification for description of potential maintenance activities.

D. Warranty:

1. Contractor shall warranty planting installation for a period of one full year after date of substantial completion against failures and defects including death and unsatisfactory growth as determined by the Architect, unless such failure is determined to be due to the Owner's negligence in following the Contractor's recommended maintenance procedure.
 - a. Failures and defects may include, but are not limited to, death and unsatisfactory growth including impacts from cold weather, structural failures including plants falling or blowing over, and deterioration of metals, metal finishes and other materials beyond normal weathering.
2. At a minimum, remedial warranty actions shall include:
 - a. Immediate removal and replacement of dead plant material unless required to plant in the next growing season,
 - b. Plant replacement for plants that are 25% dead or in an unhealthy condition at the end of the warranty period, and
 - c. A limit of up to one replacement of each plant within the warranty period, except for losses or replacement due to failure to comply with requirements as stated herein.
3. Contractor shall regularly inspect planted areas, and shall notify the Architect if they encounter site conditions unfavorable to the health of the plants.
4. Materials for replacement shall be of the same kind as used in the original installation unless directed otherwise by the Architect. It is the Contractor's responsibility to provide documentation of warranty treatment, repair or replacement. The Contractor shall coordinate documentation and any interim inspections with the Architect.

PART 2 PRODUCTS

2.1 PLANTS

- A. Species and size identified in plant schedule, grown in climatic conditions similar to those in locality of the work.
- B. Complying with ANSI Z60.1.
- C. Labeling: at least one plant of each variety, size, and caliper with a securely attached waterproof tag bearing legible designation of common name, full scientific name, including genus, species, hybrid, variety, and cultivar where applicable.

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- D. If formal arrangements or consecutive order of plants is shown on drawings, select stock for uniform habit, height and spread, and number the labels to assure symmetry in planting.

2.2 SOIL MATERIALS

- A. Replacement Soil Mixture: soil will be required where grades are low, soil is missing, or soil has been contaminated and removed during construction.
 - 1. Pre-approved Product Basis of Design: Soilutions Topsoil Blend (505-877-0220), www.soilutions.net.
 - 2. Use of high quality local sources is preferred.

2.3 SOIL AMENDMENT MATERIALS

- A. All amounts noted below are included for purposes of bidding. Following award of the project, Contractor shall make recommendations for soil amendment materials based on results of soil samples taken from the site, and tested by a regional laboratory. Cost of testing is the responsibility of the Contractor.
- B. Water: Clean, fresh, and free of substances or matter that could inhibit vigorous growth of plants.
- C. Fertilizer
 - 1. Pre-approved Product Basis of Design: For bidding purposes assume uniform application of Nature's Bio 3-2-1-Plus over all planting pits and beds. This is a slow release organic fertilizer that shall be blended into planting backfill.
 - 2. Rates: per manufacturer's recommendations for type of plant material.
- D. Herbicides and Pesticides: Herbicides and pesticides are not required, but may be used. .
 - 1. Contractor shall submit request for use and approval to the Architect.
 - 2. Submittal shall include name of product(s) and description of use. If approved, application shall be per manufacturer's recommendations.
 - 3. Proposed herbicides and pesticides shall have a least hazardous (Tier III) ranking.
- E. Compost:
 - 1. Pre-approved Product Basis of Design: where compost is called for on the drawings or in the specifications, assume use of Soilutions Premium Compost (505-877-0220), www.soilutions.net.
 - 2. Use of high quality local sources is preferred.
 - 3. For purposes of bidding, where plant pits that are located in native soil areas, pits are to be backfilled with a blend of native soil removed from the pit and premium compost. The ratio shall be 2/3 native soil blended with 1/3 premium compost.

2.4 MULCH MATERIALS

- A. As indicated on the drawings.

2.5 ACCESSORIES

- A. Wrapping Materials: Burlap.
- B. Tree staking is not required, but may be used.
 - 1. Upright Stakes: rough-sawn, sound, new hardwood or softwood, free of knots, holes, cross grain and other defects, 2" x 2" nominal by length indicated. Pointed at one end.
 - 2. Flexible Ties: wide rubber or elastic band or straps of length required to reach stakes. Use of wire or cable tie and guys is not permitted.
- C. Weed Control Barrier: non-woven geotextile filter fabric. Acceptable products include polyspun and needle-punched nonwoven fabrics, 3.5 oz./sq. yd. minimum, composed of fibers in a random network that form a high-strength, high permittivity, dimensionally stable fabric. Fabric shall be inert to biological degradation and resist naturally encountered chemicals, alkalis, and acids.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that prepared subsoil is ready to receive plants.
- B. Verify that finish grades are properly set to accommodate plant material and mulch.
- C. Verify that irrigation has been installed and is operable.

3.2 PREPARATION

- A. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.
- B. Prepare subsoil to eliminate uneven areas. Maintain profiles and contours. Make changes in grade gradual. Blend slopes into level areas.
- C. Remove foreign materials, weeds and undesirable plants and their roots. Remove contaminated subsoil.
- D. Scarify subsoil to a depth of 3 inches or as noted on the plans where plants are to be placed. Repeat cultivation in areas where equipment, used for hauling and spreading topsoil, has compacted subsoil.

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- E. Dig pits for plant material to the depth and widths as noted on the drawings.
- F. Finish Grading: Grade planting areas to a uniform surface plane with a loose texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

3.3 PLANTING

- A. Excavation:
 - 1. Excavate circular planting pits with sides sloping inward at a 45-degree angle. Excavations with vertical sides are not acceptable. Trim perimeter of bottom leaving center of bottom area slightly raised to support root ball and assist in drainage away from center. Do not further disturb the base. Scarify sides of planting pit.
 - 2. Excavate planting pits to the size noted on the drawings.
 - 3. Keep excavations covered or otherwise protected when unattended by Contractor's personnel.
 - 4. Fill excavations with water and allow to percolate away before positioning trees and shrubs.
- B. Planting Backfill Mixture:
 - 1. Remove debris 3" or larger from excavated native soil that is to be used for backfill. Irregular clods of soil and natural material debris like wood or rocks are acceptable as part of the backfill composition. Do not screen soil.
 - 2. Create planting backfill mixture by blending native soil with compost at a rate of 2/3 native soil and 1/3 compost for use as backfill around plants.
- C. Setting Plants
 - 1. Before planting, verify that root flare is visible at top of root ball according to ANSI Z60.1. If not visible, remove soil from the top and top sides of the root ball until the top-most root is exposed emerging from the trunk. This is the plant's root flare.
 - 2. Before planting, Contractor shall selectively remove stem or trunk girdling roots, kinked roots and damaged roots by cutting cleanly. The Contractor is required to selectively prune roots as necessary to eliminate future girdling.
 - 3. Set stock plumb in center of planting pit with root flare 1 inch above adjacent finish grade.
 - 4. Backfill with planting mixture around rootball in 4" maximum layers - tamping to settle soil and eliminate voids and air pockets.
 - 5. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. repeat watering until no more water is absorbed.
 - 6. Continue watering until no more water is absorbed.
 - 7. Apply fertilizer per manufacturer's recommendations.

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- D. Planting on Slopes: when planting on slopes, set the plant so the root flare is on the uphill side and is flush with surrounding soil on the slope. The edge of the root ball on the downhill side will be above the surrounding soil. Apply enough soil to cover the downhill side of the root ball.

3.4 PLANT SUPPORT

- A. If tree staking is being used, brace plants vertically as indicated on drawings.

3.5 TREE PRUNING

- A. Perform pruning of trees as recommended in ANSI A300, but only at the direction of the Architect. Do not prune trees prior to delivery to the site, or without approval of the Architect

3.6 MAINTENANCE

- A. Provide maintenance at no extra cost to Owner; Owner will pay for water.
- B. Maintain plant life for three months after Date of Substantial Completion.
- C. Irrigate sufficiently to saturate root system and prevent soil from drying out.
- D. Cultivate and weed plant beds and tree pits.
- E. Remove dead or broken branches and treat pruned areas or other wounds.
- F. Control growth of weeds. Primary control shall be by hand removal, cultivation, and mowing. Apply herbicides as a last resort and in accordance with manufacturer's instructions.
- G. Control insect damage and disease. Apply pesticides only as a last resort and in accordance with manufacturers instructions.
- H. Remedy damage from use of herbicides and pesticides.
- I. Replace mulch when deteriorated.
- J. Maintain staking. Repair or replace accessories when required.

END OF SECTION

SECTION 33 1000 – WATER UTILITIES

PART 1 GENERAL

1.1 WORK INCLUDED

- A. Pipes, materials, and appurtenances for potable water systems.
- B. Installation.

1.2 REFERENCES

- A. New Mexico Standard Specifications for Public Works Construction.
- B. AWWA:
 - 1. C110: Gray iron and ductile iron fittings 3" through 48" for water and other liquids.
 - 2. C600: Installation of Ductile-Iron Water Mains and Their Appurtenances.
 - 3. C605: Underground Installation of Polyvinyl Chloride (PVC) Pressure Pipe and Fittings for Water.
 - 4. C700: Cold water meters - displacement type.
 - 5. C900: Polyvinyl chloride (PVC) pressure pipe 4" through 12" for water.
- C. ASTM:
 - 1. A370: Mechanical Testing of steel products.
 - 2. A536: Ductile iron castings.
 - 3. D1330: Rubber sheet gaskets.
 - 4. D1598: Test for time-of-failure of plastic pipe under long-term hydrostatic pressure.
 - 5. D1599: Test for short-term rupture strength of plastic pipe, tubing and fittings.
 - 6. D1784: Polyvinyl chloride (PVC) compound and chlorinated polyvinyl chloride (PVC) compounds, rigid.
 - 7. D1869: Rubber rings for asbestos cement pipe.
 - 8. D2239: Polyethylene plastic pipe.
 - 9. D3139: Joints for plastic pressure pipes using flexible elastomeric seals.
 - 10. E8: Tension testing for metallic materials.
- D. Other: City of Santa Public Utilities Department Water Division Construction Standards and Specifications. These specifications are applicable to all public water line construction.

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1.3 SUBMITTALS

- A. Submittals per Section 01 33 00.
- B. Manufacturer's installation recommendations.
- C. Pipe Materials, valves, fittings, reduced pressure backflow preventers, heated enclosures and other appurtenances associated with water line construction.

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:

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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. 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.
 2. 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:
 - a. ANSI A21.51 (AWWA C151).
 - b. ASTM A536, Grade 60-42-10.
 - c. Ductile iron pipe shall meet ANSI/AWWA A21.51/C151 specifications:
 2. Fittings:
 - a. Ductile iron, ANSI A21.10 (AWWA C111).
 - b. ASTM A536, Grade 80-60-03 or 70-50-05.
 - c. Hydrostatic test: Rated at minimum 150psi.
 3. Threaded connections: ANSI B2.1 NPT.

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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 4" to 12":
 - a. AWWA C900:
 - (1) All Sizes: SDR 18 or as scheduled.
 - (2) Pressure Class: 235 psi or as scheduled.
2. Joints:
 - a. Gasket bell end: ASTM D3139 for plastic pressure pipes using elastomeric seals.
 - b. Gaskets: ASTM F477, elastomeric.
 - c. Solvent-Cement: Manufacturer's standard; use only where specifically scheduled, shown on Drawings or approved by Engineer.

C. Service Lines:

1. Copper Tubing:
 - a. ASTM B88 Type K Copper Tubing
2. Joints:
 - a. Compression fittings.
 - b. Compatible with heavy duty copper service fittings.

2.2 APPURTENANCES

A. Fire Hydrants:

1. Reference City of Santa Fe Public Utilities Department Standards and Specifications

B. One Manufacturer's hydrant wrench supplied with each hydrant installed.

C. Resilient Wedge Gate Valves:

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1. Size as shown on Drawings.
 2. Mueller, Clow, Waterous, American Darling, Resilient Wedge Gate Valves or Engineer approved equivalent.
 3. Valves shall conform to AWWA C-509 and comply with its latest revisions.
 4. The wedge shall be cast iron, fully encapsulated in molded rubber including the guides. The bronze stem nut must be rigidly enclosed in the wedge to maintain alignment.
 5. The stem shall have two O-rings above and one O-ring below the collar. Stem seats must be replaceable with the valve under pressure.
 6. The stem material shall be stainless steel (AISI420) or Engineer-approved equivalent.
 7. The waterway shall be full size to allow for tapping use; no cavities or depressions are permitted in the seat area.
 8. Valve body and bonnet shall be electrostatically applied, fusion bonded and epoxy coated, both inside and out, by the valve manufacturer. The coating shall meet the requirements of AWWA C-550. Coating to be applied only at the valve manufacturer's facilities.
 9. The bonnet bolts shall not be exposed to the environment or, alternatively, be in 316 stainless steel.
 10. O-ring style seals shall be used as gaskets on the bonnet and on the stuffing box.
 11. All valves must be tested by hydrostatic pressure equal to the requirements in the AWWA C-509 specifications prior to shipment from the manufacturer.
 12. 2-inch AWWA operating nut for valves in below-ground service; handwheel for above-ground service.
 13. Mechanical joint ends for pipe or as shown on drawings.
- D. Reduced Pressure Backflow Prevention Devices:
1. 2-1/2" and Larger: Zurn Wilkins Model 375A with flange connection and OS&Y valves or approved equal
 2. 1"-2" Zurn Wilkins Model 375XL or approved equal.
- E. 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.
- F. Cover marked "Water". Tapping Sleeves:
1. Minimum working pressure 250 psi.
 2. Mechanical joint type.

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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.

G. 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.

H. Heated Enclosures:

1. Comply with ASSE 1060 performance requirements for outdoor enclosures for backflow prevention assemblies
2. Insulation shall have minimum R value of 9.
3. Heating equipment shall be furnished and designed by the manufacturer of the enclosure to maintain an interior temperature of +40°F with an outside temperature of -30°F.
4. The heater shall be designed for installation to the concrete base with mounting hardware provided.
5. The heater shall be suitable for installation underneath a reduce pressure backflow prevention device and designed to sustain water spray without damage or impeding the performance of the heater.
6. The heater shall be provided with a thermostat adjustable from +40°F to +100°F. The thermostat, all conduit and wiring fittings provided shall be suitable for “water-tight” installation.

I. Tracer Wire:

1. Conductor shall be solid or stranded copper per ASTM B-1, B-3, or B-8.
2. Insulation of conductor shall be yellow, high molecular weight polyethylene (HMWPE).
3. The temperature rating of the tracer wire shall be 75 degrees Celsius, dry and wet. The voltage rating shall be 600 Volts.
4. Tracer wire shall be installed on all water, sanitary sewer storm drain, and gas lines.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General:

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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 4'-0" as measured from the established road grade or the surface of the permanent improvement to the top of the barrels of the pipe.
- C. Pipe Laying:

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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 City of Santa Fe Public Utilities Department, Water Division Construction Standards and Specifications.

G. Pipe Sleeves:

1. For all pipes passing through concrete or masonry.
2. Install where practical before concrete is placed.
3. Sleeve seal: watertight, modular sealing element when sleeve is placed in slabs with one side against soil.

H. Buried pipe anchorage:

1. Anchors, joint harness or other acceptable means of preventing pipe movement whether indicated or not required for:
 - a. Unlugged bell and spigot or all unflanged tees.
 - b. Branches.
 - c. Bends deflecting 22 ½ degrees or more.
 - d. Plugs and caps.
 - e. Fittings in fills or unstable ground.

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- f. Valves
 - g. Fire hydrant branches. All joints from main to fire hydrant shall be restrained
- I. Valves: Installed as shown on Drawings with valve boxes and joint restraint.
- J. Fire hydrants: As indicated on Drawings with Joint restraint.

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 150 psi for one hour per 1,000 linear foot of pipe or 2 hours minimum
- C. Testing Equipment:
- 1. Pressure gauge used to perform pressure test shall be a digital type gauge with the ability to display testing pressure to one hundredth (1/100) of a psi. The pressure gauge shall be rated for at least the required testing pressure.
 - 2. All equipment for use in supplying water for the testing procedure shall be for potable water use only. A suitable amount of chlorine should be added to the storage device in order to disinfect such device. Prior notice will be given to engineer of method used for supplying water for testing.
 - 3. When existing water mains are used to supply test water, they should be protected from backflow contamination by temporarily installing a double check-valve assembly between the test and supply main, or by other means approved by the Engineer.
 - 4. All testing equipment are subject to and shall be disinfected per New Mexico Standard specifications for Public Works Construction 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.
 - 2. Plug ends as required.
 - 3. Water shall be applied by means of a pump connected to the pipe in a satisfactory manner.
 - 4. All air shall be expelled from the pipe prior to pressure testing.

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5. No installation will be accepted unless the leakage is less than the number of gallons per hour as determined by the formula in New Mexico Standard specifications for Public Works Construction Section 801:
6. Leakage shall be defined as the quantity of water that must be supplied into the pipe section being tested to maintain a pressure within 5 psi of the specified leakage-test pressure after the pipe has been filled with water and the air in the pipeline has been expelled.
7. All joints showing visible leaks shall be properly repaired. Any cracked or defective pipes, fittings, valves, or hydrants discovered in consequence of this pressure test shall be removed and replaced by the Contractor with sound material, and the test repeated.
8. Retest repaired joints, pipes and fittings until system is tight and test results are satisfactory to the Engineer.
9. Pipe testing and preparation for use should strictly follow AWWA C605 Section. 7: Preparation for use.
10. Ductile Iron pipe hydrostatic pipe testing shall be done in accordance with section C600: Installation of Ductile-Iron Water Mains and Their Appurtenances. Previously described procedures for hydrostatic testing is for Polyvinyl Chloride (PVC) pipe only.

3.3 PIPE SCHEDULE

- A. PVC Pipe:
 1. Pipe sizes 4" through 12" , AWWA C900, SDR 18, pressure class 235 Or Engineer acceptable alternate:
- B. End connections to be push-on joints unless otherwise indicated on the Drawings.
- C. Repair and/or replacement of existing water lines damaged during construction: Material generally to match existing or at least quality required by this section.
- D. Provide sizes as shown on the Drawings.

3.4 VALVE SCHEDULE

- A. Resilient wedge gate valves: as shown on the Drawings.

END OF SECTION

SECTION 33 30 00 – SANITARY SEWER UTILITIES

PART 1 GENERAL

1.1 DESCRIPTION OF WORK

- A. All sanitary sewer work and materials in this Section shall be performed in accordance with the Contract Drawings and the New Mexico Standard Specifications for Public Works Construction, 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 sanitary sewer collection lines
 - 2. Installation of building sanitary sewer service laterals
 - 3. Installation of precast concrete manholes
- 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.

1.2 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
 - 2. Precast concrete manholes

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 Schedule 40 PVC and conform to the requirements of ASTM D-3034. Joints shall be push-on rubber gaskets according to ASTM D-1785 and ASTM D-2466.

2.2 FRAMES AND COVERS

- A. Castings for frames and covers shall be made of grey iron conforming to the sizes and types shown on the Contract Drawings.

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- B. Castings for catch basins shall meet requirements for AASHTO M105, Grade 30 and be free of cracks, casting faults, or other composition defects. Castings shall be furnished with burrs ground off at foundry.
- C. Frames and grates for sanitary manholes shall be bedded on mortar to prevent movement or "rocking".
- D. Covers shall be stamped "SEWER" on the top to indicate manhole type.

2.3 PRECAST CONCRETE STRUCTURES

- A. Sanitary manholes shall conform to the sizes and types shown on the Contract Drawings.
- B. Sanitary manholes shall be precast steel reinforced concrete with monolithic base fabricated in conformance with ASTM C478. The reinforced steel shall conform to the latest ASTM A185 Standards.
- C. Rubber gasket seals shall be provided between each precast concrete riser to ensure a watertight seal.
- D. Rubber boots or mechanical seals such as LINK SEAL as manufactured Thunderline Corp., Belleville, MI, or approved equal, shall be provided at all cutouts for pipe inverts to provide a positive watertight seal.

2.4 PIPE BEDDING AND TRENCH BACKFILL MATERIALS

- A. Bedding Material is specified in Section 31 00 00 of these specifications.
- B. Backfill Material: Backfill material shall be placed above the pipe bedding to subgrade elevations. This material shall be on-site soil, free of organics, wood, metals, cobbles greater than 6 inches, and deleterious materials, and shall be subject to the approval of the Engineer.

PART 3 EXECUTION

3.1 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. Inlet structures shall be constructed as shown on the Contract Drawings. The elevations of the inverts and tops of the structures shall not vary more than 1/2 inch from the proposed grades.

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- D. Pipes entering and exiting the sanitary manhole shall be neatly cut flush with the inside of the manhole. Irregularities and rough edges inside the manhole shall be pointed with non-shrink grout.
- E. Channels across the floor of the sanitary manholes shall be shaped to provide for smooth flow between pipe inverts. Concrete and mortar shall be used to obtain a channel having a smooth, fine textured surface.
- F. Frames shall be embedded in mortar and bear uniformly on the structure such that there is no movement or "rocking".
- G. The contractor shall verify the elevation of all points of connection to existing building services or sewer lines prior to installation of sanitary sewer pipe. Any discrepancies shall be brought to the attention of the engineer immediately.
- H. Tracer Wire:
 - 1. Conductor shall be solid or stranded copper per ASTM B-1, B-3, or B-8.
 - 2. Insulation of conductor shall be yellow, high molecular weight polyethylene (HMWPE).
 - 3. The temperature rating of the tracer wire shall be 75 degrees Celsius, dry and wet. The voltage rating shall be 600 Volts.
 - 4. Tracer wire shall be installed on all water, sanitary sewer storm drain and gas lines.

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 cooperate with the Engineer as required to facilitate testing and inspection of the work. The Contractor shall clean and "lamp" the lines under the inspection of the Engineer before final acceptance of the work by the Owner.
- B. The Contractor shall provide necessary materials, equipment, and labor to perform the tests as described herein.
- C. The sanitary sewer lateral shall be tested for exfiltration.

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D. Exfiltration

1. The Contractor shall provide a leakage test using the "Low Pressure Air Test" method. Prior to the acceptance test, the Contractor shall have cleaned the pipeline. The Contractor shall furnish test plugs, air compressor, and personnel for conducting the test. Pipe shall be plugged between two manhole locations. Air shall be slowly supplied to the plugged pipe installation until the pressure reaches 5.0 psi. A minimum time of two minutes shall be allowed for temperature stabilization.
2. The air supply will then be cut off. The rate of air loss shall then be determined by measuring the time interval for the pressure to drop from 4.5 to 3.5 psi. Test gages shall be graduated to the nearest 0.10 psi.
3. The pipeline shall be considered acceptable when the time interval for the pressure drop from 4.5 psi to 3.5 psi exceeds the corresponding allowable times given in the following table:

MINIMUM ALLOWABLE

PIPE DIAMETER	TIME INTERVAL
<u>(inches)</u>	<u>(minutes: Seconds)</u>
6	2:15
8	4:00

- E. The Contractor shall maintain the pipe and structures in clean working condition until final acceptance by the Owner.

END OF SECTION

SECTION 33 40 00 – 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. Earthwork: SECTION 31 00 00

1.3 QUALITY ASSURANCE:

- A. All work and materials shall be in full accordance with the New Mexico Standard Specifications for Public Works Construction, Latest Edition, including all updates, and all applicable laws, codes, and regulations.

PART 2 PRODUCTS

2.1 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 26. 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 manufacturers representative to ensure proper installation practices are understood and used by contractor. Contractor shall notify engineer, in writing, the date and time of the completion of this meeting.
 - 2. Pipe must be smooth interior, with a manning's n value not greater than 0.013.
 - 3. HDPE shall use bell & spigot, with water-tight type joints.
 - 4. HDPE shall conform with the following specifications:
 - a. ASTM F 405 - Standard Specifications for Corrugated Polyethylene Pipe and Fittings.
 - b. ASTM F 667 - Standard Specifications for Large Diameter Corrugated Polyethylene Pipe Fittings.
 - c. ASTM D 2321 - Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity Flow Applications.

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- d. ASTM D 3212 - Standard Specification for Joints for Drain and Sewer Plastic Pipe Using Flexible Elastomeric Joints.
- e. ASTM F 1417, Standard Test Method for Installation Acceptance of Plastic Gravity Sewer Lines Using Low-pressure Air.
- f. ASTM F 477-95, Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
- g. 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 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 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 groove (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.
- B. The contractor shall verify the elevation of all points of connection to existing storm drains prior to installation of any storm drain pipe. Any discrepancies shall be brought to the attention of the engineer immediately.
- C. Tracer Wire:
 - 1. Conductor shall be solid or stranded copper per ASTM B-1, B-3, or B-8.
 - 2. Insulation of conductor shall be yellow, high molecular weight polyethylene (HMWPE).
 - 3. The temperature rating of the tracer wire shall be 75 degrees Celsius, dry and wet. The voltage rating shall be 600 Volts.
 - 4. Tracer wire shall be installed on all water, sanitary sewer storm drain and gas lines.

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.

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- C. Mortar joints shall only be used where 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 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