

PROJECT MANUAL

**Wake County Mini City EMS Station
RFB #26-075**

**4704 Hargrove Road
RALEIGH, NC
27616**

**Bid/Permit Construction Documents
August 17, 2026**



632 Pershing Road
Raleigh, NC 27608

EA Project Number: 2506
Book 2 of 2
Divisions 21 through 31

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SECTION 21 05 00 – COMMON WORK RESULTS FOR FIRE SUPPRESSION**PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Piping materials and installation instructions common to most piping systems.
 - 2. Sleeves.
 - 3. Escutcheons.
 - 4. Grout.
 - 5. Fire-suppression equipment and piping demolition.
 - 6. Equipment installation requirements common to equipment sections.
 - 7. Painting and finishing.
 - 8. Concrete bases.
 - 9. Supports and anchorages.

1.3 DEFINITIONS

- A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.
- B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
- C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
- D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in chases.
- E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

1.4 SUBMITTALS

- A. Product Data: For the following:
 - 1. Piping materials Escutcheons.
 - 2. Welding certificates.

1.5 QUALITY ASSURANCE

- A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."
- B. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
 - 1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
 - 2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

1.7 COORDINATION

- A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for fire-suppression installations.
- B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.
- C. Coordinate requirements for access panels and doors for fire-suppression items requiring access that are concealed behind finished surfaces.
- D. Coordinate locations of flexible couplings on both sides of fire rated partitions to limit the number of sway braces required.
- E. Coordinate all seismic braces with other trades and building structure.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the manufacturers specified.

2.2 PIPE, TUBE, AND FITTINGS

- A. Refer to individual Division 21 piping Sections for pipe, tube, and fitting materials and joining methods.
- B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.3 JOINING MATERIALS

- A. Refer to individual Division 21 piping Sections for special joining materials not listed below.
- B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
 - 1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch (3.2-mm) maximum thickness unless thickness or specific material is indicated.
 - a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
 - b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
 - 2. AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.
- C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
- D. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.
- E. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
- F. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.

- G. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.4 SLEEVES

- A. Galvanized-Steel Sheet: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.
- B. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.
- C. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

2.5 ESCUTCHEONS

- A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.
- B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.
- C. One-Piece, Cast-Brass Type: With set screw.
 - 1. Finish: Polished chrome-plated.
- D. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.
 - 1. Finish: Polished chrome-plated.
- E. Split-Plate, Stamped-Steel Type: With exposed-rivet hinge, set screw or spring clips, and chrome-plated finish.
- F. One-Piece, Floor-Plate Type: Cast-iron floor plate.
- G. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

PART 3 - EXECUTION

3.1 PIPING SYSTEMS - COMMON REQUIREMENTS

- A. Install piping according to the following requirements and Division 21 Sections specifying piping systems.
- B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are to be used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- 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 to permit valve servicing.
- G. Install piping at indicated slopes.
- H. Install piping free of sags and bends.
- I. Install fittings for changes in direction and branch connections.
- J. Install piping to allow application of insulation.
- K. Select system components with pressure rating equal to or greater than system operating pressure.
- L. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:
 - 1. New Piping:
 - a. Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.

- b. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
- c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.
- d. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type with concealed or exposed-rivet hinge and set screw or spring clips.
- e. Bare Piping in Equipment Rooms: One-piece, stamped-steel type with set screw or spring clips.
- f. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.
- M. Sleeves are not required for core-drilled holes.
- N. Permanent sleeves are not required for holes formed by removable PE sleeves.
- O. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.
- P. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.
 - 1. Cut sleeves to length for mounting flush with both surfaces.
- Q. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Penetration Firestopping" for materials. Provide flexible couplings within 12" of either side of wall to eliminate sleeves in these locations.
- R. Verify final equipment locations for roughing-in.

3.2 PIPING JOINT CONSTRUCTION

- A. Join pipe and fittings according to the following requirements and Division 21 Sections specifying piping systems.
- B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.
- E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.
- F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.
- H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.3 PAINTING

- A. Painting of fire-suppression systems, equipment, and components is specified in Division 09 Sections "Interior Painting" and "Exterior Painting."
- B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.4 ERECTION OF METAL SUPPORTS AND ANCHORAGES

- A. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor fire-suppression materials and equipment.
- B. Field Welding: Comply with AWS D1.1.
- C. Provide seismic restraints per NFPA 13 chapter 9.

END OF SECTION 21 05 00

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SECTION 21 05 48 – SEISMIC RESTRAINTS FOR FIRE PROTECTION**PART 1 - GENERAL**

- 1.1 The Contractor shall be responsible for providing restraints to resist the earthquake effects on the fire protection system. The requirements for these restraints are found in Chapter 16, entitled "*Structural Design*", of the North Carolina Building Code and Chapter 9 of the 2002 edition of NFPA 13.

PART 2 - PRODUCT

- 2.1 The Contractor is required to include the installation of seismic products and a complete seismic design. The seismic design will be certified by an independent registered professional Structural Engineer in the state of North Carolina. The design will show the attachment of the components directly to the structure. Any intermediate supports required, i.e. roof curbs, housekeeping pads, structural bases or rails, will also be included with the complete design. Quantity of sway bracing required for the suspended piping and ductwork should be obtained from a qualified source regularly engaged in seismic design and structural code requirements. Location of sway braces for piping will be determined during the construction phase to coordinate with actual job site conditions and restrictions.
- 2.2 The Seismic Engineer shall be registered in the same state as the structure and shall have a minimum of five years experience in seismic restraint design. The products used for seismic restraint design will only be products approved or listed for such application. The Seismic Engineer will design around attachment devices, i.e. anchor bolts, concrete anchors, sheet metal screws, A36 steel, etc. that are locally and readily available to the installing Contractor.
- 2.3 Periodic inspections will be by the Seismic Engineer or an approved and qualified individual appointed by the Seismic Engineer and who has been educated and trained in structural and seismic design. Training will be provided to the installing Contractor on correction installation and application of seismic restraint devices.
- 2.4 Upon completion of the project, documentation will be required certifying the installation of the seismic restraint devices. This will be done by the Seismic Engineer or his pre-qualified representative.

PART 3 - EXECUTION

- 3.1 The Contractor shall include shop drawings of the specific methods of seismic restraint to be used for this project before installation of piping and equipment.
- 3.2 Review of the seismic design and shop drawings by the Seismic Engineer/Architect or his agent shall not relieve the Contractor of his responsibility to comply with the seismic or any other requirements of the North Carolina State Building Code.

Seismic Restraint Design Criteria for Components and Systems

Refer to Drawing G101 for seismic data.

Identification of Components required to be Restrained:

- **Per NFPA 13, 2013. Piping larger than 2".**

Design Objective

Components shall be attached such that the component forces are transferred to the building structure either directly or through an intermediate support. Component seismic attachments shall be bolted, welded or otherwise positively attached. All intermediate supports that are not manufactured items will be designed by an independent structural engineer. All seismic attachments will be designed without consideration of frictional resistance produced by the effects of gravity. The construction documents shall include sufficient information relating to the attachment to verify compliance.

Design Requirements:

A code analysis will be done in order to determine the Seismic Design Criteria. A schedule will be produced identifying the components required to be restrained as well as any intermediate supports that may be required for the project. All this information will be certified by an independent professional engineer qualified to do seismic restraint design, registered in the same state as the project and not affiliated with any manufacturers.

Product Requirements:

Products used to meet the seismic restraint design requirements will be approved or listed products only. Manufacturers will be for fasteners, anchor bolts, concrete anchors or restrained isolators. Any intermediate supports will be required to be design using the design seismic force. The intermediate support products provided by manufacturers must be certified by the manufacturer for the design seismic force.

Agent Requirement:

A qualified source approved by the independent design engineer to provide training to the installing contractor, do jobsite inspections and provide close out documentation. This source will also provide legitimate pricing for design and products to the contractors at bid time. The proposals will include estimated quantities of seismic products required in order for the contractors to have a base to estimate their labor.

END OF SECTION 21 05 48

SECTION 21 10 00 - WET-PIPE SPRINKLER 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. This Section specifies wet-pipe sprinkler systems for buildings and structures.
- B. Products specified in this Section with installation not in Contract include sprinkler cabinets with spare sprinklers and sprinkler wrenches. Deliver to the Owner's maintenance personnel.

1.3 DEFINITIONS

- A. Pipe sizes used in this Section are nominal pipe size (NPS) specified in inches. Tube sizes are standard tube size specified in inches. Equivalent or approximate SI (metric) sizes are indicated in millimeters (mm) in parentheses.
- B. Working plans as used in this Section refer to documents (including drawings and calculations) prepared pursuant to requirements in NFPA 13 for obtaining approval of authority having jurisdiction.
- C. Other definitions for fire protection systems are included in referenced NFPA standards.

1.4 SYSTEM DESCRIPTION

- A. Wet-Pipe Sprinkler System: System with automatic sprinklers attached to piping system containing water and connected to water supply so that water discharges immediately from sprinklers when they are opened by fire.
- B. Sprinkler System Protection Limits: All spaces within areas indicated. Include closets, toilet areas, and special applications areas.

1.5 SYSTEM PERFORMANCE REQUIREMENTS

- A. Obtain approval from Authority Having Jurisdiction for fire protection systems specified.
- B. Minimum Pipe Sizes: Not smaller than sizes indicated for connection to water supply piping, standpipes, and branches from standpipes to sprinklers.
- C. The water supply is to be taken from the flow data shown on the drawings. Margin of Safety for Available Water Flow and Pressure: safety factor of 10 psi less static, 10 psi less residual and 10% less flow, including losses through water service piping, valves and backflow preventers. Calculations start at the existing water lines outside the buildings and must include all valves and fittings. Use the "1.4 Rule", and include a 100 gpm hose stream allowance for light hazard and 250 gpm hose stream for ordinary hazard. Limit water velocity to 25fps, except use 18fps for any segment with a vane type water-flow switch (to comply with UL listing).
- D. Hydraulically design sprinkler systems according to:
 - 1. Sprinkler System Occupancy Light and Ordinary Hazard Group I Classification.
 - 2. Minimum Density Requirements for Automatic Sprinkler System Hydraulic Design: Refer to sprinkler design data on Sheet FP001.
 - 3. Maximum Sprinkler Spacing: Refer to sprinkler design data on Sheet FP001.

- E. Components and Installation: Capable of producing piping systems with the following minimum working pressure ratings except where indicated otherwise.
 - 1. Sprinkler Systems: 175 psig.

1.6 SUBMITTALS

- A. Product data for fire protection system components. Include the following:
 - 1. Valves.
 - 2. Specialty valves, accessories, and devices.
 - 3. Alarm devices. Include electrical data.
 - 4. Sprinklers, escutcheons, and guards. Include sprinkler flow characteristics, mounting, finish, and other data.
- B. The sprinkler contractor must submit "working plans or shop/fabrication drawings" and hydraulic calculations to Sigma Engineered Solutions for review, prior to any fabrication or installation work. No fabrication and or installation shall begin without approved submittals from Sigma Engineered Solutions, PC and AHJ.
- C. Test reports and certificates as described in NFPA 13. Include "Contractor's Material & Test Certificate for Aboveground Piping" and "Contractor's Material & Test Certificate for Underground Piping."
- D. Maintenance data for each type of fire protection specialty specified, for inclusion in Operating and Maintenance Manual specified in Division 1.
- E. 2 copies of NFPA 25 "Standard for Inspection, Testing and Maintenance of Water Based Fire Protection Systems." Deliver to Owner's maintenance personnel.

1.7 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Firms whose equipment, specialties, and accessories are listed by product name and manufacturer in UL Fire Protection Equipment Directory and FM Approval Guide and that conform to other requirements indicated.
- B. Listing/Approval Stamp, Label, or Other Marking: On equipment, specialties, and accessories made to specified standards.
- C. Listing and Labeling: Equipment, specialties, and accessories that are listed and labeled.
 - 1. The Terms "Listed" and "Labeled": As defined in "National Electrical Code," Article 100.
 - 2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.
- D. Comply with requirements of authority having jurisdiction for submittals, approvals, materials, hose threads, installation, inspections, and testing.
- E. Comply with requirements of the North Carolina Department of Insurance for submittals, approvals, materials, installation, inspections, and testing.
- F. Installer's Qualifications: Firms qualified to install and alter fire protection piping, equipment, specialties, and accessories, and repair and service equipment. A qualified firm is one that is experienced (minimum of 5 previous projects similar in size and scope to this Project) in such work, familiar with precautions required, and in compliance with the requirements of the authority having jurisdiction. Submit evidence of qualifications to the Sigma Engineered Solutions upon request"
- G. NFPA Standards: Equipment, specialties, accessories, installation, and testing complying with the following:
 - 1. NFPA 13 "Standard for the Installation of Sprinkler Systems."
 - 2. NFPA 26 "Recommended Practice for the Supervision of Valves Controlling Water Supplies for Fire Protection."
 - 3. NFPA 70 "National Electrical Code."

PART 2 - PRODUCTS**2.1 MANUFACTURERS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Specialty Valves:
 - a. ASCOA Fire Systems, Figgie International Co.
 - b. Central Sprinkler Corp.
 - c. Firematic Sprinkler Devices, Inc.
 - d. Gem Sprinkler Co. Div., Grinnell Corp.
 - e. Globe Fire Sprinkler Corp.
 - f. Reliable Automatic Sprinkler Co., Inc.
 - g. Star Sprinkler Corp.
 - h. Viking Corp.
 2. Sprinklers:
 - a. ASCOA Fire Systems, Figgie International Co.
 - b. Firematic Sprinkler Devices, Inc.
 - c. Gem Sprinkler Co. Div., Grinnell Corp.
 - d. Globe Fire Sprinkler Corp.
 - e. Reliable Automatic Sprinkler Co., Inc.
 - f. Star Sprinkler Corp.
 - g. Victaulic Company of America.
 - h. Viking Corp.
 3. Grooved Couplings for Steel Piping:
 - a. Grinnell Supply Sales Co., Grinnell Corp.
 - b. Gustin-Bacon Div., Tyler Pipe Subsid., Tyler Corp.
 - c. Sprink-Line by Sprink, Inc.
 - d. Stockham Valves and Fittings, Inc.
 - e. Victaulic Company of America.

2.2 PIPES AND TUBES

- A. Refer to Part 3 Articles "Piping Installation" for identification of systems where pipe and fitting materials specified below are used.
- B. All piping shall be as follows:
1. 2 1/2" through 8" pipe size: ASTM A135, schedule 10 black steel, grooved or welded joints and fittings.
 2. 2" and smaller pipe size: ASTM A135, schedule 40 black steel pipe with standard weight cast iron or malleable iron threaded joints and fittings, or schedule 40 black steel welded joints and fittings. Mechanical tees, grooved or threaded may not be used.

2.3 PIPE AND TUBE FITTINGS

- A. NO SADDLE FITTINGS AND NO MECHANICAL TEES.
- B. Cast-Iron Threaded Flanges: ASME B16.1, Class 125, raised ground face, bolt holes spot faced.
- C. Ductile-Iron and Gray-Iron Flanged Fittings: AWWA C110, 125-psig minimum pressure rating, with AWWA C104 cement-mortar lining.
- D. Cast-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern, with threads according to ASME B1.20.1.
- E. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern, with threads according to ASME B1.20.1.

- F. Grooved-End Fittings for Ductile-Iron Pipe: ASTM A 536 ductile-iron or ASTM A 47 malleable-iron, AWWA pipe-size, designed to accept AWWA C606 grooved couplings. Include cement lining or Food and Drug Administration (FDA)-approved interior coating.
- G. Steel Fittings: ASTM A 234/A 234M, seamless or welded; ASME B16.9, butt welding; or ASME B16.11, socket-welding type for welded joints.
- H. Steel Flanges and Flanged Fittings: ASME B16.5.
- I. Grooved-End Fittings for Steel Pipe: UL-listed and FM-approved, ASTM A 536, Grade 65-45-12 ductile iron or ASTM A 47 Grade 32510 malleable iron, with grooves or shoulders designed to accept grooved couplings.

2.4 JOINING MATERIALS

- A. Flanged Joints for Ductile-Iron Pipe and Ductile-Iron or Cast-Iron Fittings: AWWA C115 ductile-iron or gray-iron pipe flanges, rubber gaskets, and high-strength steel bolts and nuts.
- B. Couplings for Grooved-End Steel Pipe and Grooved-End Ferrous Fittings: UL 213, AWWA C606, ASTM A 536 ductile-iron or ASTM A 47 malleable-iron housing, with enamel finish. Include synthetic-rubber gasket with central-cavity, pressure-responsive design; ASTM A 183 carbon-steel bolts and nuts; and locking pin, toggle, or lugs to secure grooved pipe and fittings.
- C. Couplings for Grooved-End Ductile-Iron Pipe and Fittings: UL 213, AWWA C606, ASTM A 536 ductile-iron housing, with enamel finish. Include synthetic-rubber gasket with central-cavity, pressure-responsive design, and ASTM A 183 carbon-steel bolts and nuts to secure grooved pipe and fittings.

2.5 SPRINKLERS

- A. NO FLEX SPRINKLER HEADS.
- B. Automatic Sprinklers: With heat-responsive element conforming to:
 - 1. UL 199, for applications except residential.
- C. Sprinkler types and categories are as indicated on plans and as required by application. Furnish automatic sprinklers with nominal 1/2-inch orifice for "Ordinary" temperature classification rating except where otherwise indicated and required by application.
- D. Sprinkler types, features, and options include:
 - 1. Quick response recessed pendent sprinklers in lay in ceiling.
 - 2. Quick response upright sprinklers in areas with exposed piping.
 - 3. Quick response sidewall sprinklers where indicated.
- E. Sprinkler Finishes: As indicated on plans.
- F. Sprinkler Escutcheons: Materials, types, and finishes for following sprinkler mounting applications. Escutcheons for concealed type sprinklers are specified with sprinklers. In lay in ceilings escutcheons shall be suitable for easy ceiling tile replacement.
 - 1. Ceiling Pendent Mounting: Finish as indicated on plans, 2-piece, recessed.

2.6 SPECIALTY SPRINKLER FITTINGS

- A. Specialty Fittings: UL-listed and FM-approved, made of steel, ductile iron, or other materials compatible with system materials and applications where used.
- B. Mechanical-Cross Fittings: UL 213, ductile-iron housing with pressure-responsive gaskets, bolts, and threaded or grooved outlets.
- C. Drop-Nipple Fittings: UL 1474, with threaded inlet, threaded outlet, and seals; adjustable.
- D. Sprinkler Alarm Test Fittings: Ductile-iron housing with 1-1/2-inch inlet and outlet, integral test valves, combination orifice and sight glass, and threaded or locking-lug ends.

2.7 PRESSURE GAGES

- A. Pressure Gages: UL 393, 3-1/2 to 4-1/2 inches diameter dial with dial range of 0-250 psig.

2.8 SEISMIC SWAY BRACES

- A. Pressure Gages: UL 393, 3-1/2 to 4-1/2 inches diameter dial with dial range of 0-250 psig.

PART 3 - EXECUTION

3.1 VALVE APPLICATIONS

- A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:
 - 1. Shutoff Duty: Use ball or butterfly valves.
 - 2. Throttling Duty: Use globe, ball, or butterfly valves.

3.2 JOINT CONSTRUCTION

- A. Grooved-End Pipe and Grooved-End Fitting Joints: Use grooved-end fittings and grooved couplings that are made by the same manufacturer and that are listed for use together. Groove pipe and assemble joints with grooved coupling, gasket, lubricant, and bolts according to coupling and fitting manufacturer's written instructions.
 - 1. Groove Type: Rolled.
- B. Dissimilar Materials Piping Joints: Make joints using adapters compatible with both piping materials.

3.3 PIPING INSTALLATIONS

- A. Locations and Arrangements: Drawings indicate general location and arrangement of piping and are provided for informational purposes. Every fitting and length of pipe may not be shown on the contract documents. It is the contractor's responsibilities to review the contract documents and coordinate the fire protection system installation with the building architectural, structural, mechanical and electrical systems. The contractor shall create "working plans or shop/fabrication drawings" showing all pipe sizes, location, routing and elevations that are a result of this coordination effort. Necessary offsets or changes in pipe routing from the contract documents that are required to properly install the fire protection system as to take up minimum space shall be furnished and install by the contractor with no additional expense to the owner. Install piping as indicated, as far as practical.
 - 1. Deviations from approved "working plans" for sprinkler piping require written approval from authority with jurisdiction. File written approval with the engineer/owner's representative prior to deviating from approved "working plans."
- B. Use approved fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.
- C. Install unions adjacent to each valve in pipes 2 inches and smaller. Unions are not required on flanged devices or in piping installations using grooved couplings.
- D. Install flanges or flange adapters on valves, apparatus, and equipment having 2-1/2-inch and larger connections.

- E. Install "Inspector's Test Connections" in sprinkler piping, complete with shutoff valve, sized and located according to NFPA 13 and plumb to gang drain. Inspector's Test Connections should be operable from floor level whenever possible. Test Connections are permitted to be locked if vandalism is a concern.
- F. Install sprinkler piping with drains for complete system drainage, and isolation drainage as shown on the Drawings.
- G. Install sprinkler zone control valves, test assemblies, and drain headers.
- H. Install ball drip valves to drain piping between fire department connections and check valves, and where indicated. Drain to suitable drain or outside building.
- I. Install alarm devices including water motor gongs in piping systems.
- J. Hangers and Supports: Comply with NFPA 13. Install according to NFPA 13 and NFPA 14.
 - 1. Install hanger and support spacing and locations for steel piping joined with grooved mechanical couplings according to manufacturer's written instructions for rigid systems.
- K. Install pressure gages on riser or feed main, and at each sprinkler test connection. Include pressure gages with connection not less than 1/4 inch and with soft metal-seated globe valve, arranged for draining pipe between gage and valve. Install gages to permit removal, and install where they will not be subject to freezing.

3.4 SPECIALTY SPRINKLER FITTING INSTALLATIONS

- A. Install specialty sprinkler fittings according to manufacturer's written instructions.

3.5 SPRINKLER APPLICATIONS

- A. Rooms without Ceilings: Upright style sprinklers.
- B. Rooms with Ceilings: Pendent style recessed sprinklers.

3.6 SPRINKLER INSTALLATIONS

- A. Install sprinklers in patterns indicated.
- B. Install sprinklers in suspended ceilings in center of acoustical panels and tiles unless otherwise indicated.
- C. Do not install wet-type sprinklers in areas subject to freezing. Heat tracing is NOT acceptable for dry pipe or preaction valve freeze protection. A heated room or closet must be provided to protect these vital components.

3.7 CONNECTIONS

- A. Connect to specialty valves, hose valves, specialties, and accessories.
- B. Connect water supplies to standpipe and sprinkler systems.

3.8 FIELD QUALITY CONTROL

- A. Perform field acceptance tests of each fire protection system.
 - 1. Flush, test, and inspect sprinkler piping systems according to NFPA 13 Chapter "System Acceptance."
- B. Replace piping system components that do not pass test procedures specified, then retest to demonstrate compliance. Repeat procedure until satisfactory results are obtained.
 - 1. Report test results promptly and in writing to Engineer and Owner.
 - 2. Report test results promptly and in writing to authority having jurisdiction when required.

3.9 CLEANING

- A. Clean dirt and debris from sprinklers. Replace sprinklers having paint other than factory finish with new sprinklers. Cleaning and reuse of painted sprinklers is prohibited.

3.10 COMMISSIONING

- A. Starting Procedures: Follow manufacturer's written procedures. If no procedures are prescribed by manufacturer, proceed as follows:
 - 1. Verify that specialty valves, trim, fittings, controls, and accessories have been installed correctly and operate correctly.
 - 2. Verify that specified tests of piping are complete.
 - 3. Check that damaged sprinklers and sprinklers with paint or coating not specified have been replaced with new, correct type of sprinklers.
 - 4. Check that sprinklers are correct type, have correct finish and temperature ratings, and have guards where required for applications.
 - 5. Check that potable water supplies have correct type of backflow preventer.
 - 6. Check that fire department connections have threads compatible with local fire department equipment and have correct pressure rating.
 - 7. Fill wet-pipe sprinkler systems with water.
 - 8. Energize circuits to electrical equipment and devices.
 - 9. Adjust operating controls and pressure settings.
- B. Coordinate with fire alarm system tests. Operate systems as required.

3.11 PAINTING

- A. Exposed piping in sprinkler riser mechanical room shall be painted Sherwin Williams Apple Red 511.
- B. Exposed piping in rooms and corridors shall be painted to match existing finishes. Coordinate with owner.

3.12 DEMONSTRATION

- A. Demonstrate equipment, specialties, and accessories. Review operating and maintenance information.
- B. Schedule demonstration with at least 7 days' advance notice.

END OF SECTION 21 10 00

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SECTION 22 05 00 - COMMON WORK RESULTS FOR PLUMBING**PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Piping materials and installation instructions common to most piping systems.
 - 2. Dielectric fittings.
 - 3. Escutcheons.
 - 4. Grout.
 - 5. Equipment installation requirements common to equipment sections.
 - 6. Concrete bases.
 - 7. Supports and anchorages.

1.3 DEFINITIONS

- A. Finished Spaces: Spaces other than plumbing and electrical equipment rooms, furred spaces, pipe chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.
- B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and plumbing equipment rooms.
- C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
- D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in chases.
- E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

1.4 SUBMITTALS

- A. Plumbing Piping
- B. Plumbing Fixtures & Equipment
- C. Plumbing Insulation

PART 2 - PRODUCTS**2.1 PIPE, TUBE, AND FITTINGS**

- A. Refer to individual Division 22 piping Sections for pipe, tube, and fitting materials and joining methods.
- B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.2 JOINING MATERIALS

- A. Refer to individual Division 22 piping Sections for special joining materials not listed below.

- B. Pipe-Flange Gasket Materials: ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch (3.2-mm) maximum thickness unless thickness or specific material is indicated.
- C. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.
- D. Brazing Filler Metals: AWS A5.8, BCuP Series or BAg1, unless otherwise indicated.
- E. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

2.3 DIELECTRIC FITTINGS

- A. Dielectric Unions: Not accepted.

2.4 SLEEVES

- A. Galvanized-Steel Sheet: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.
- B. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.
- C. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
- D. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
 - 1. Underdeck Clamp: Clamping ring with set screws.

2.5 ESCUTCHEONS

- A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.
- B. One-Piece, Cast-Brass Type: With set screw.
 - 1. Finish: Polished chrome-plated.
- C. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.
 - 1. Finish: Polished chrome-plated.

2.6 GROUT

- A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
 - 1. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
 - 2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
 - 3. Packaging: Premixed and factory packaged.

2.7 WIRING METHODS

- A. Where electrical wiring is required by this trade other than covered by Division 26, the contractor shall refer to the same wiring materials and methods as specified under Division 26. No Exceptions.

PART 3 - EXECUTION

3.1 PIPING SYSTEMS - COMMON REQUIREMENTS

- A. Install piping according to the following requirements and Division 22 Sections specifying piping systems.

- B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- 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 to permit valve servicing.
- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections.
- I. Install piping to allow application of insulation.
- J. Select system components with pressure rating equal to or greater than system operating pressure.
- K. Install escutcheons for penetrations of walls, ceilings, and floors.
- L. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.
- M. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Penetration Firestopping" for materials.
- N. Verify final equipment locations for roughing-in.
- O. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.
- P. Provide video of underground waste at or prior to substantial completion.

3.2 PIPING JOINT CONSTRUCTION

- A. Join pipe and fittings according to the following requirements and Division 22 Sections specifying piping systems.
- B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.
- E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.
- F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- G. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.3 PIPING CONNECTIONS

- A. Make connections according to the following, unless otherwise indicated:
 - 1. Install unions, in piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment.

2. Install flanges, in piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment.
3. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.
4. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

3.4 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

- A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.
- B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.
- C. Install plumbing equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.
- D. Install equipment to allow right of way for piping installed at required slope.

3.5 CONCRETE BASES

- A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.
 1. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger in both directions than supported unit.
 2. All concrete pads shall have 1-1/2" beveled edges.
 3. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of the base.

3.6 ERECTION OF METAL SUPPORTS AND ANCHORAGES

- A. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor plumbing materials and equipment.

3.7 GROUTING

- A. Mix and install grout for plumbing equipment base bearing surfaces, pump and other equipment base plates, and anchors.
- B. Clean surfaces that will come into contact with grout.
- C. Provide forms as required for placement of grout.
- D. Avoid air entrapment during placement of grout.
- E. Place grout, completely filling equipment bases.
- F. Place grout on concrete bases and provide smooth bearing surface for equipment.
- G. Place grout around anchors.
- H. Cure placed grout.

END OF SECTION 22 05 00

SECTION 22 05 19 - METERS AND GAGES FOR PLUMBING PIPING**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. Thermometers.
 - 2. Gages.
 - 3. Test plugs.
- B. Related Sections:
 - 1. Division 22 Section "Facility Water Distribution Piping" for domestic and fire-protection water service meters outside the building.
 - 2. Division 22 Section "Domestic Water Piping" for domestic and fire-protection water service meters inside the building.
 - 3. Division 23 Section "Facility Natural-Gas Piping" for gas meters.

1.3 DEFINITIONS

- A. CR: Chlorosulfonated polyethylene synthetic rubber.
- B. EPDM: Ethylene-propylene-diene terpolymer rubber.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated; include performance curves.
- B. Shop Drawings: Schedule for thermometers and gages indicating manufacturer's number, scale range, and location for each.
- C. Product Certificates: For each type of thermometer and gage, signed by product manufacturer.

PART 2 - PRODUCTS**2.1 METAL-CASE, LIQUID-IN-GLASS THERMOMETERS**

- 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. Palmer - Wahl Instruments Inc.
 - 2. Trerice, H. O. Co.
 - 3. Weiss Instruments, Inc.
 - 4. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.
- B. Case: Die-cast aluminum 9 inches (229 mm) long.
- C. Tube: Red or blue reading, mercury or organic-liquid filled, with magnifying lens.
- D. Tube Background: Satin-faced, nonreflective aluminum with permanently etched scale markings.
- E. Window: Glass.
- F. Connector: Adjustable type, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device.

- G. Stem: Copper-plated steel, aluminum, or brass for thermowell installation and of length to suit installation.
- H. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

2.2 THERMOWELLS

- A. Manufacturers: Same as manufacturer of thermometer being used.
- B. Description: Pressure-tight, socket-type metal fitting made for insertion into piping and of type, diameter, and length required to hold thermometer.

2.3 PRESSURE GAGES

- 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. AMETEK, Inc.; U.S. Gauge Div.
 - 2. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Div.
 - 3. Ernst Gage Co.
 - 4. Eugene Ernst Products Co.
 - 5. KOBOLD Instruments, Inc.
 - 6. Marsh Bellofram.
 - 7. Miljoco Corp.
 - 8. Noshok, Inc.
 - 9. Palmer - Wahl Instruments Inc.
 - 10. REO TEMP Instrument Corporation.
 - 11. Terice, H. O. Co.
 - 12. Weiss Instruments, Inc.
 - 13. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.
 - 14. WIKA Instrument Corporation.
 - 15. Winters Instruments.
- B. Direct-Mounting, Dial-Type Pressure Gages: Indicating-dial type complying with ASME B40.100.
 - 1. Case: Liquid-filled type, drawn steel or cast aluminum 4-1/2-inch diameter.
 - 2. Pressure-Element Assembly: Bourdon tube, unless otherwise indicated.
 - 3. Pressure Connection: Brass, NPS 1/4 (DN 8), bottom-outlet type unless back-outlet type is indicated.
 - 4. Movement: Mechanical, with link to pressure element and connection to pointer.
 - 5. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.
 - 6. Pointer: Red or other dark-color metal.
 - 7. Window: Glass.
 - 8. Ring: Brass or Stainless steel
 - 9. Accuracy: Grade A, plus or minus 1 percent of middle scale.
 - 10. Vacuum-Pressure Range: 30-in. Hg of vacuum to 15 psig of pressure (100 kPa of vacuum to 103 kPa of pressure).
 - 11. Range for Fluids under Pressure: Two times operating pressure.
- C. Pressure-Gage Fittings:
 - 1. Valves: NPS 1/4 (DN 8) brass or stainless-steel needle type.
 - 2. Snubbers: ASME B40.5, NPS 1/4 (DN 8) brass bushing with corrosion-resistant, porous-metal disc of material suitable for system fluid and working pressure.

2.4 TEST PLUGS

- 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. Flow Design, Inc.
 2. MG Piping Products Co.
 3. National Meter, Inc.
 4. Peterson Equipment Co., Inc.
 5. Sisco Manufacturing Co.
 6. Trerice, H. O. Co.
 7. Watts Industries, Inc.; Water Products Div.
- B. Description: Corrosion-resistant brass or stainless-steel body with core inserts and gasketed and threaded cap, with extended stem for units to be installed in insulated piping.
- C. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F (3450 kPa at 93 deg C).
- D. Core Inserts: One or two self-sealing rubber valves.
1. Insert material for water service at 20 to 200 deg F (minus 7 to plus 93 deg C) shall be CR.
 2. Insert material for water service at minus 30 to plus 275 deg F (minus 35 to plus 136 deg C) shall be EPDM.

PART 3 - EXECUTION

3.1 THERMOMETER APPLICATIONS

- A. Install thermometers in the outlet of each domestic, hot-water storage tank.
- B. Provide the following temperature ranges for thermometers:
1. Domestic Hot Water: 30 to 180 deg F, with 2-degree scale divisions (Minus 1 to plus 82 deg C, with 1-degree scale divisions).
 2. Domestic Cold Water: 0 to 100 deg F, with 2-degree scale divisions (Minus 18 to plus 38 deg C, with 1-degree scale divisions).

3.2 GAGE APPLICATIONS

- A. Install pressure gages for discharge of each pressure-reducing valve.

3.3 INSTALLATIONS

- A. Install direct-mounting thermometers and adjust vertical and tilted positions.
- B. Install thermowells with socket extending to center of pipe and in vertical position in piping tees where thermometers are indicated.
- C. Install direct-mounting pressure gages in piping tees with pressure gage located on pipe at most readable position.
- D. Install needle-valve and snubber fitting in piping for each pressure gage.
- E. Install test plugs in tees in piping.
- F. Install permanent indicators on walls or brackets in accessible and readable positions.
- G. Install connection fittings for attachment to portable indicators in accessible locations.
- H. Install thermometers and gages adjacent to machines and equipment to allow service and maintenance for thermometers, gages, machines, and equipment.
- I. Adjust faces of thermometers and gages to proper angle for best visibility.

END OF SECTION 22 05 19

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SECTION 22 05 23 - GENERAL-DUTY VALVES FOR PLUMBING PIPING**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes:
 - 1. Brass ball valves.
 - 2. Bronze ball valves.
 - 3. Bronze swing check valves.

1.2 SUBMITTALS

- A. Product Data: For each type of valve indicated.

1.3 QUALITY ASSURANCE

- A. ASME Compliance: ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
- B. NSF Compliance: NSF 61 for valve materials for potable-water service.

PART 2 - PRODUCTS**2.1 GENERAL REQUIREMENTS FOR VALVES**

- A. Refer to valve schedule articles for applications of valves.
- B. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- C. Valve Sizes: Same as upstream piping unless otherwise indicated.
- D. Valve Actuator Types:
 - 1. Gear Actuator: For quarter-turn valves NPS 8 (DN 200) and larger.
 - 2. Handwheel: For valves other than quarter-turn types.
 - 3. Handlever: For quarter-turn valves NPS 6 (DN 150) and smaller except plug valves.
- E. Valves in Insulated Piping: With 2-inch (50-mm) stem extensions and the following features:
 - 1. Quarter Turn Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.
 - 2. Butterfly Valves: With extended neck.
- F. Valve-End Connections:
 - 1. Flanged: With flanges according to ASME B16.1 for iron valves.
 - 2. Solder Joint: With sockets according to ASME B16.18.
 - 3. Threaded: With threads according to ASME B1.20.1.

2.2 BRASS BALL VALVES

- A. Two-Piece, Full-Port, Brass Ball Valves with Brass Trim:
 - 1. Description:
 - a. Standard: MSS SP-110.
 - b. SWP Rating: 150 psig (1035 kPa).
 - c. CWP Rating: 600 psig (4140 kPa).
 - d. Body Design: Two piece.

- e. Body Material: Forged brass.
- f. Ends: Threaded.
- g. Seats: PTFE or TFE.
- h. Stem: Brass.
- i. Ball: Chrome-plated brass.
- j. Port: Full.

2.3 BRONZE BALL VALVES

A. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim:

- 1. Description:
 - a. Standard: MSS SP-110.
 - b. SWP Rating: 150 psig (1035 kPa).
 - c. CWP Rating: 600 psig (4140 kPa).
 - d. Body Design: Two piece.
 - e. Body Material: Bronze.
 - f. Ends: Threaded.
 - g. Seats: PTFE or TFE.
 - h. Stem: Bronze.
 - i. Ball: Chrome-plated brass.
 - j. Port: Full.

2.4 BRONZE SWING CHECK VALVES

A. Class 125, Bronze Swing Check Valves with Bronze Disc:

- 1. Description:
 - a. Standard: MSS SP-80, Type 3.
 - b. CWP Rating: 200 psig (1380 kPa).
 - c. Body Design: Horizontal flow.
 - d. Body Material: ASTM B 62, bronze.
 - e. Ends: Threaded.
 - f. Disc: Bronze.

PART 3 - EXECUTION

3.1 VALVE INSTALLATION

- A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- B. Locate valves for easy access and provide separate support where necessary.
- C. Install valves in horizontal piping with stem at or above center of pipe.
- D. Install valves in position to allow full stem movement.

3.2 ADJUSTING

- A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.3 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

- A. If valve applications are not indicated, use the following:
 - 1. Shutoff Service: Ball, butterfly valves.
 - 2. Throttling Service: ball valves.
 - 3. Pump-Discharge Check Valves:

- a. Bronze swing check valves with bronze disc.
- B. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP class or CWP ratings may be substituted.
- C. Select valves, except wafer types, with the following end connections:
 - 1. For Copper Tubing, NPS 2 (DN 50) and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.
 - 2. For Copper Tubing, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends except where threaded valve-end option is indicated in valve schedules below.
 - 3. For Copper Tubing, NPS 5 (DN 125) and Larger: Flanged ends.

3.4 DOMESTIC, HOT- AND COLD-WATER VALVE SCHEDULE

- A. Pipe NPS 2-1/2" and Smaller:
 - 1. Quarter-turn bronze ball valves with soldered or threaded ends
 - 2. Quarter-turn angled valves with soldered or threaded ends.
- B. Pipe NPS 3" and Larger:
 - 1. Butterfly valves.

3.5 SANITARY-WASTE AND STORM-DRAINAGE VALVE SCHEDULE

- 1. Iron Valves, NPS 2-1/2 to NPS 4 (DN 65 to NPS 100): May be provided with threaded ends instead of flanged ends.
- 2. Iron Swing Check Valves: Class 125, nonmetallic-to-metal seats.
- 3. Iron Swing Check Valves with Closure Control: Class 125, lever and spring

END OF SECTION 22 05 23

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SECTION 22 05 29 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT**PART 1 - GENERAL****1.1 SUMMARY**

- A. This Section includes the following:
 - 1. Steel pipe hangers and supports.
 - 2. Trapeze pipe hangers.
 - 3. Metal framing systems.
 - 4. Thermal-hanger shield inserts.
 - 5. Fastener systems.
 - 6. Equipment supports.

1.2 DEFINITIONS

- A. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

1.3 SUBMITTALS

- A. Product Data: For the following:
 - 1. Steel pipe hangers and supports.
 - 2. Thermal-hanger shield inserts.
 - 3. Powder-actuated fastener systems.

1.4 QUALITY ASSURANCE

- A. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX.

PART 2 - PRODUCTS**2.1 STEEL PIPE HANGERS AND SUPPORTS**

- A. Description: MSS SP-58, Types 1 through 58, factory-fabricated components. Refer to Part 3 "Hanger and Support Applications" Article for where to use specific hanger and support types.
- B. Galvanized, Metallic Coatings: Pregalvanized or hot dipped.
- C. Nonmetallic Coatings: Plastic coating, jacket, or liner.
- D. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion for support of bearing surface of piping.

2.2 TRAPEZE PIPE HANGERS

- A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural-steel shapes with MSS SP-58 hanger rods, nuts, saddles, and U-bolts.

2.3 METAL FRAMING SYSTEMS

- A. Description: MFMA-3, shop- or field-fabricated pipe-support assembly made of steel channels and other components.
- B. Coatings: Manufacturer's standard finish, unless bare metal surfaces are indicated.
- C. Nonmetallic Coatings: Plastic coating, jacket, or liner.

2.4 THERMAL-HANGER SHIELD INSERTS

- A. Description: 100-psig- (690-kPa-) minimum, compressive-strength insulation insert encased in sheet metal shield.
- B. Insulation-Insert Material for Cold Piping: Water-repellent treated, Water-repellent treated, ASTM C 533, Type I calcium silicate or ASTM C 552, Type II cellular with vapor barrier.
- C. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate or ASTM C 552, Type II cellular glass.
- D. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.
- E. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
- F. Insert Length: Extend 2 inches (50 mm) beyond sheet metal shield for piping operating below ambient air temperature.

2.5 FASTENER SYSTEMS

- A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
- B. Mechanical-Expansion Anchors: Insert-wedge-type zinc-coated steel, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

2.6 EQUIPMENT SUPPORTS

- A. Description: Welded, shop- or field-fabricated equipment support made from structural-steel shapes.

2.7 MISCELLANEOUS MATERIALS

- A. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
- B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
 - 1. Properties: Nonstaining, noncorrosive, and nongaseous.
 - 2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

- A. Specific hanger and support requirements are specified in Sections specifying piping systems and equipment.
- B. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system Sections.
- C. Use hangers and supports with galvanized, metallic coatings for piping and equipment that will not have field-applied finish.
- D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- E. Use padded hangers for piping that is subject to scratching.
- F. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated stationary pipes, NPS 1/2 to NPS 30 (DN 15 to DN 750).

2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of 120 to 450 deg F (49 to 232 deg C) pipes, NPS 4 to NPS 16 (DN 100 to DN 400), requiring up to 4 inches (100 mm) of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24 (DN 20 to DN 600), requiring clamp flexibility and up to 4 inches (100 mm) of insulation.
4. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8 (DN 15 to DN 200).
5. U-Bolts (MSS Type 24): For support of heavy pipes, NPS 1/2 to NPS 30 (DN 15 to DN 750).
6. Pipe Saddle Supports (MSS Type 36): For support of pipes, NPS 4 to NPS 36 (DN 100 to DN 900), with steel pipe base stanchion support and cast-iron floor flange.
7. Single Pipe Rolls (MSS Type 41): For suspension of pipes, NPS 1 to NPS 30 (DN 25 to DN 750), from 2 rods if longitudinal movement caused by expansion and contraction might occur.
8. Complete Pipe Rolls (MSS Type 44): For support of pipes, NPS 2 to NPS 42 (DN 50 to DN 1050), if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
- G. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 20 (DN 20 to DN 500).
 2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20 (DN 20 to DN 500), if longer ends are required for riser clamps.
- H. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches (150 mm) for heavy loads.
 2. Steel Clevises (MSS Type 14): For 120 to 450 deg F (49 to 232 deg C) piping installations.
- I. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
 2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joint construction to attach to top flange of structural shape.
 3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
 4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
 5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
 6. C-Clamps (MSS Type 23): For structural shapes.
 7. Welded-Steel Brackets: For support of pipes from below, or for suspending from above by using clip and rod. Use one of the following for indicated loads:
 - a. Light (MSS Type 31): 750 lb (340 kg).
 - b. Medium (MSS Type 32): 1500 lb (680 kg).
 - c. Heavy (MSS Type 33): 3000 lb (1360 kg).
 8. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
 9. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
- J. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
 2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
 3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.
- K. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches (32 mm).
 2. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41 roll hanger with springs.
 3. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from base support.
- L. Comply with MSS SP-69 for trapeze pipe hanger selections and applications that are not specified in piping system Sections.
- M. Comply with MFMA-102 for metal framing system selections and applications that are not specified in piping system Sections.
- N. Use powder-actuated fasteners mechanical-expansion anchors instead of building attachments where required in concrete construction.

3.2 HANGER AND SUPPORT INSTALLATION

- A. Steel Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.
- B. Trapeze Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated trapeze pipe hangers.
1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.
 2. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D1.1.
- C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled metal framing systems.
- D. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.
- E. Fastener System Installation:
1. Install powder-actuated fasteners in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
 2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
- F. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.
- G. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
- H. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- I. Install lateral bracing with pipe hangers and supports to prevent swaying.
- J. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 (DN 65)] and larger and at changes in direction of piping. Install concrete

inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

- K. Load Distribution: Install hangers and supports so piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- L. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.9 (for building services piping) are not exceeded.
- M. Insulated Piping: Comply with the following:
 - 1. Attach clamps and spacers to piping.
 - a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
 - b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
 - c. Do not exceed pipe stress limits according to ASME B31.9 for building services piping.
 - 2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
 - 3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
 - 4. Shield Dimensions for Pipe: Not less than the following:
 - a. NPS 1/4 to NPS 3-1/2 (DN 8 to DN 90): 12 inches (305 mm) long and 0.048 inch (1.22 mm) thick.
 - b. NPS 4 (DN 100): 12 inches (305 mm) long and 0.06 inch (1.52 mm) thick.
 - c. NPS 5 and NPS 6 (DN 125 and DN 150): 18 inches (457 mm) long and 0.06 inch (1.52 mm) thick.
 - d. NPS 8 to NPS 14 (DN 200 to DN 350): 24 inches (610 mm) long and 0.075 inch (1.91 mm) thick.
 - e. NPS 16 to NPS 24 (DN 400 to DN 600): 24 inches (610 mm) long and 0.105 inch (2.67 mm) thick.
 - 5. Pipes NPS 8 (DN 200) and Larger: Include wood inserts.
 - 6. Insert Material: Length at least as long as protective shield.
 - 7. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.3 EQUIPMENT SUPPORTS

- A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.
- B. Grouting: Place grout under supports for equipment and make smooth bearing surface.
- C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.4 METAL FABRICATIONS

- A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.
- B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.
- C. Field Welding: Comply with AWS D1.1 procedures for shielded metal arc welding, appearance and quality of welds, and methods used in correcting welding work, and with the following:
 - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - 2. Obtain fusion without undercut or overlap.
 - 3. Remove welding flux immediately.

4. Finish welds at exposed connections so no roughness shows after finishing and contours of welded surfaces match adjacent contours.

3.5 ADJUSTING

- A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

3.6 PAINTING

- A. Touch Up: 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 (0.05 mm).
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 22 05 29

SECTION 22 05 48 - VIBRATION AND SEISMIC CONTROLS FOR PLUMBING PIPING AND EQUIPMENT**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes:
 - 1. Elastomeric isolation pads.
 - 2. Elastomeric isolation mounts.
 - 3. Restrained elastomeric isolation mounts.
 - 4. Open-spring isolators.
 - 5. Housed-spring isolators.
 - 6. Restrained-spring isolators.
 - 7. Housed-restrained-spring isolators.
 - 8. Pipe-riser resilient supports.
 - 9. Resilient pipe guides.
 - 10. Elastomeric hangers.
 - 11. Spring hangers.
 - 12. Snubbers.
 - 13. Restraint channel bracings.
 - 14. Restraint cables.
 - 15. Seismic-restraint accessories.
 - 16. Mechanical anchor bolts.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Delegated-Design Submittal: For each vibration isolation and seismic-restraint device.
 - 1. Include design calculations and details for selecting vibration isolators and seismic restraints complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For professional engineer.
- B. Welding certificates.
- C. Field quality-control reports.

1.4 QUALITY ASSURANCE

- A. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.
- B. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- C. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are unavailable, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

PART 2 - PRODUCTS**2.1 PERFORMANCE REQUIREMENTS**

- A. Seismic-Restraint Loading:
 - 1. Reference Drawing Sheet S001 for seismic requirements.

2.2 ELASTOMERIC ISOLATION PADS

- A. Elastomeric Isolation Pads:
 - 1. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
 - 2. Size: Factory or field cut to match requirements of supported equipment.
 - 3. Pad Material: Oil and water resistant with elastomeric properties.
 - 4. Surface Pattern: Waffle pattern.
 - 5. Infused nonwoven cotton or synthetic fibers.
 - 6. Load-bearing metal plates adhered to pads.

2.3 ELASTOMERIC ISOLATION MOUNTS

- A. Double-Deflection, Elastomeric Isolation Mounts:
 - 1. Mounting Plates:
 - a. Top Plate: Encapsulated steel load transfer top plates, factory drilled and threaded.
 - b. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to support structure.
 - 2. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.4 RESTRAINED ELASTOMERIC ISOLATION MOUNTS

- A. Restrained Elastomeric Isolation Mounts:
 - 1. Description: All-directional isolator with seismic restraints containing two separate and opposing elastomeric elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
 - a. Housing: Cast-ductile iron or welded steel.
 - b. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.5 RESTRAINED-SPRING ISOLATORS

- A. Freestanding, Laterally Stable, Open-Spring Isolators with Vertical-Limit Stop Restraint:
 - 1. Housing: Steel housing with vertical-limit stops to prevent spring extension due to weight being removed.
 - a. Base with holes for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig (3447 kPa).
 - b. Top plate with threaded mounting holes.
 - c. Internal leveling bolt that acts as blocking during installation.
 - 2. Restraint: Limit stop as required for equipment and authorities having jurisdiction.
 - 3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 - 4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 - 5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 - 6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.6 PIPE-RISER RESILIENT SUPPORT

- A. Description: All-directional, acoustical pipe anchor consisting of two steel tubes separated by a minimum 1/2-inch- (13-mm-) thick neoprene.
 - 1. Vertical-Limit Stops: Steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions.
 - 2. Maximum Load Per Support: 500 psig (3.45 MPa) on isolation material providing equal isolation in all directions.

2.7 RESILIENT PIPE GUIDES

- A. Description: Telescopic arrangement of two steel tubes or post and sleeve arrangement separated by a minimum 1/2-inch- (13-mm-) thick neoprene.
 - 1. Factory-Set Height Guide with Shear Pin: Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.8 ELASTOMERIC HANGERS

- A. Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods:
 - 1. Frame: Steel, fabricated with a connection for an upper threaded hanger rod and an opening on the underside to allow for a maximum of 30 degrees of angular lower hanger-rod misalignment without binding or reducing isolation efficiency.
 - 2. Dampening Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel to steel contact.

2.9 SPRING HANGERS

- A. Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression:
 - 1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
 - 2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 - 3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 - 4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 - 5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 - 6. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
 - 7. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
 - 8. Self-centering hanger-rod cap to ensure concentricity between hanger rod and support spring coil.

2.10 SNUBBERS

- A. Description: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.
 - 1. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and stud-wedge or female-wedge type.
 - 2. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
 - 3. Maximum 1/4-inch (6-mm) air gap, and minimum 1/4-inch- (6-mm-) thick resilient cushion.

2.11 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 and other matching components and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.12 RESTRAINT CABLES

- A. Restraint Cables: ASTM A603 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.

2.13 SEISMIC-RESTRAINT ACCESSORIES

- A. Hanger-Rod Stiffener: Reinforcing steel angle clamped to hanger rod.
- B. 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.
- C. 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.
- D. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.
- E. 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 E488.

PART 3 - EXECUTION

3.1 APPLICATIONS

- A. Multiple Pipe Supports: Secure pipes 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 due to seismic forces.
- C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength is adequate to carry present and future static and seismic loads within specified loading limits.

3.2 VIBRATION CONTROL AND 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. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.
- C. Comply with requirements in Section 077200 "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.
- D. Equipment Restraints:
 - 1. Install seismic snubbers on plumbing equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
 - 2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch (3.2 mm).

3. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.
- E. Piping Restraints:
 1. Comply with requirements in MSS SP-127.
 2. Space lateral supports a maximum of 40 feet (12 m) o.c., and longitudinal supports a maximum of 80 feet (24 m) o.c.
 3. Brace a change of direction longer than 12 feet (3.7 m).
- F. Install cables so they do not bend across edges of adjacent equipment or building structure.
- G. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.
- H. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.
- I. 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.
- J. 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.
- K. Drilled-in Anchors:
 1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
 2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
 3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
 4. Set anchors to manufacturer's recommended torque, using a torque wrench.
 5. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.3 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

- A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Section 221116 "Domestic Water Piping" for piping flexible connections.

3.4 PLUMBING SYSTEMS REQUIRING SEISMIC CONTROL

- A. Waste and Ventilation piping.
- B. Roof Leaders
- C. Supply Water Piping
- D. Natural Gas Piping.

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Perform tests and inspections with the assistance of a factory-authorized service representative:
- C. Tests and Inspections:
 1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
 2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless post connection testing has been approved), and with at least seven days' advance notice.

3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
5. Test to 90 percent of rated proof load of device.
6. Measure isolator restraint clearance.
7. Measure isolator deflection.
8. Verify snubber minimum clearances.
- D. Remove and replace malfunctioning units and retest as specified above.
- E. Prepare test and inspection reports.

3.6 ADJUSTING

- A. Adjust isolators after piping system is at operating weight.
- B. Adjust limit stops on restrained-spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

END OF SECTION 22 05 48

SECTION 22 05 53 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT**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. Warning signs and labels.
 - 2. Valve Tags
 - 3. Pipe labels.

1.3 SUBMITTAL

- A. Product Data: For each type of product indicated.

PART 2 - PRODUCTS**2.1 PIPE LABELS**

- A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.
- B. Pre-tensioned Pipe Labels: Pre-coiled, semi-rigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.
- C. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.
 - 1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
 - 2. Lettering Size: At least 1-1/2 inches (38 mm) high.

2.2 VALVE TAGS

- A. Valve Tags: Stamped or engraved with 1/4-inch (6.4-mm) letters for piping system abbreviation and 1/2-inch (13-mm) numbers.
 - 1. Tag Material: Brass, 0.032-inch (0.8-mm minimum thickness, and having predrilled or stamped holes for attachment hardware.
 - 2. Fasteners: Brass wire-link chain.
- B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch (A4) bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
 - 1. Valve-tag schedule shall be included in operation and maintenance data.

2.3 EQUIPMENT LABELLING

- A. Equipment Markers: Engraved phenolic plates white background and black lettering securely fastened to the equipment with sheet metal screws.

1. Terminology: Match schedules as closely as possible.
2. Data:
 - a. Name and plan number.
 - b. Date of Installation.
 - c. Design capacity.
3. Size: 4-1/2 by 6 inches (115 by 150 mm) for equipment.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 VALVE-TAG INSTALLATION

- A. Install tags on valves and control devices in piping systems, except check valves, valves within factory-fabricated equipment units, shutoff valves, faucets, convenience and lawn-watering hose connections, and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

3.3 EQUIPMENT LABEL INSTALLATION

- A. Install or permanently fasten labels on each major item of plumbing equipment such as water heaters and pumps.
- B. Locate equipment labels where accessible and visible.

3.4 PIPE LABEL INSTALLATION

- A. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
 1. Near each valve and control device.
 2. Affixed to ceiling grid where valves are located above hard or acoustical ceilings.
 3. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
 4. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
 5. At access doors, manholes, and similar access points that permit view of concealed piping.
 6. Near major equipment items and other points of origination and termination.
 7. Spaced at maximum intervals of 50 feet (15 m) along each run. Reduce intervals to 25 feet (7.6 m) in areas of congested piping and equipment.
 8. On piping above removable acoustical ceilings. Omit intermediately spaced labels.
- B. Pipe Label Color Schedule

Service	Marker Wording	Lettering Color	Background Color	Pipe/Covering Color
Natural gas	NATURAL GAS	Black	Yellow	Yellow
Domestic cold water	DOMESTIC COLD WATER	White	Green	Blue
Domestic hot water	DOMESTIC HOT	Black	Yellow	Lt. Red

	WATER			
Domestic hot water recirculating	DOMESTIC HOT WATER RETURN	Black	Yellow	Orange
Domestic make-up water	MAKE-UP WATER	White	Green	Blue
Make-up water non-potable	NON-POTABLE MAKE-UP WATER	Black	Yellow	Purple
Sanitary drain	SANITARY DRAIN	White	Green	*
Storm drain, incl. roof drains	STORM DRAIN	White	Green	*
Plumbing vent	VENT	White	Green	*
Condensate drain	DRAIN	White	Green	*

** Pipe not painted unless exposed*

Color	Sherwin Williams Industrial & Marine Coatings Paint Number	Sherwin Williams All Surface Enamel Paint Number
Yellow	Safety Yellow SW 4084	Safety Yellow 502
Orange	Safety Orange SW 4083	N/A
Green	Cedar Green SW 4072	Hunter Green 510
Light Green	Safety Green SW 4085	Safety Green 506
Blue	N/A	Navy Blue 509
Light Blue	Safety Blue SW 4086	Safety Blue 505
Red	N/A	Apple Red 511
Light Red	Safety Red SW 4081	Safety Red 507
White	Ultra White SW 4087	Extreme White 500
Black	Black SW 4090	Black 501
Purple	Plum SW 4080	N/A

END OF SECTION 22 05 53

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SECTION 22 07 00 - PLUMBING INSULATION**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes:
 - 1. Insulation Materials:
 - a. Flexible elastomeric.
 - b. Mineral fiber.
 - 2. Insulating cements.
 - 3. Adhesives.
 - 4. Mastics.
 - 5. Sealants.
 - 6. Factory-applied jackets.
 - 7. Field-applied fabric-reinforcing mesh.
 - 8. Field-applied jackets.
 - 9. Tapes.
 - 10. Securements.
 - 11. Corner angles.

1.2 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Field quality-control reports.

1.3 QUALITY ASSURANCE

- A. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing and inspecting agency.
 - 1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

PART 2 - PRODUCTS**2.1 INSULATION MATERIALS**

- A. Comply with requirements in Part 3 schedule articles for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- D. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Aeroflex USA Inc.; Aerocel.
 - b. Armacell LLC; AP Armaflex.
 - c. RBX Corporation; Insul-Sheet 1800 and Insul-Tube 180.

- E. Mineral-Fiber, Preformed Pipe Insulation:
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Fibrex Insulations Inc.; Coreplus 1200.
 - b. Johns Manville; Micro-Lok.
 - c. Knauf Insulation; 1000 Pipe Insulation.
 - d. Manson Insulation Inc.; Alley-K.
 - e. Owens Corning; Fiberglas Pipe Insulation.
 - 2. Type I, 850 deg F (454 deg C) Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- F. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied FSK jacket complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. (40 kg/cu. m) or more. Thermal conductivity (k-value) at 100 deg F (55 deg C) is 0.29 Btu x in./h x sq. ft. x deg F (0.042 W/m x K) or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. CertainTeed Corp.; CrimpWrap.
 - b. Johns Manville; MicroFlex.
 - c. Knauf Insulation; Pipe and Tank Insulation.
 - d. Manson Insulation Inc.; AK Flex.
 - e. Owens Corning; Fiberglas Pipe and Tank Insulation.

2.2 INSULATING CEMENTS

- A. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449/C 449M.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Insulco, Division of MFS, Inc.; SmoothKote.
 - b. P. K. Insulation Mfg. Co., Inc.; PK No. 127, and Quik-Cote.
 - c. Rock Wool Manufacturing Company; Delta One Shot.

2.3 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.
- B. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Aeroflex USA Inc.; AeroSeal.
 - b. Armacell LCC; 520 Adhesive.
 - c. Foster Products Corporation, H. B. Fuller Company; 85-75.
 - d. RBX Corporation; Rubatex Contact Adhesive.
- C. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Products, Division of ITW; CP-82.
 - b. Foster Products Corporation, H. B. Fuller Company; 85-20.
 - c. ITW TACC, Division of Illinois Tool Works; S-90/80.
 - d. Marathon Industries, Inc.; 225.
 - e. Mon-Eco Industries, Inc.; 22-25.

2.4 MASTICS

- A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-C-19565C, Type II.
- B. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.
 - 1. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm (0.009 metric perm) at 43-mil (1.09-mm) dry film thickness.
 - 2. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
 - 3. Solids Content: ASTM D 1644, 59 percent by volume and 71 percent by weight.
 - 4. Color: White.
- C. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.
 - 1. Water-Vapor Permeance: ASTM F 1249, 3 perms (2 metric perms) at 0.0625-inch (1.6-mm) dry film thickness.
 - 2. Service Temperature Range: Minus 20 to plus 200 deg F (Minus 29 to plus 93 deg C).
 - 3. Solids Content: 63 percent by volume and 73 percent by weight.
 - 4. Color: White.

2.5 FACTORY-APPLIED JACKETS

- A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
 - 1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.

2.6 FIELD-APPLIED FABRIC-REINFORCING MESH

- A. Woven Polyester Fabric: Approximately 1 oz./sq. yd. (34 g/sq. m) with a thread count of 10 strands by 10 strands/sq. inch (4 strands by 4 strands/sq. mm), in a Leno weave, for equipment and pipe.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Foster Products Corporation, H. B. Fuller Company; Mast-A-Fab.
 - b. Vimasco Corporation; Elastafab 894.

2.7 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
 - 1. Width: 3 inches (75 mm).
 - 2. Thickness: 11.5 mils (0.29 mm).
 - 3. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
 - 4. Elongation: 2 percent.
 - 5. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
 - 6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

2.8 SECUREMENTS

PART 3 - EXECUTION

3.1 PREPARATION

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.
- C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.2 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment and piping including fittings, valves, and specialties.
- B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment and pipe system as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- G. Keep insulation materials dry during application and finishing.
- H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- I. Install insulation with least number of joints practical.
- J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - 1. Install insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
 - 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
 - 4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- L. Install insulation with factory-applied jackets as follows:
 - 1. Draw jacket tight and smooth.
 - 2. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.
 - 3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 4 inches (100 mm) o.c.
 - a. For below ambient services, apply vapor-barrier mastic over staples.
 - 4. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.
 - 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

- M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.
- P. For above ambient services, do not install insulation to the following:
 - 1. Vibration-control devices.
 - 2. Testing agency labels and stamps.
 - 3. Nameplates and data plates.
 - 4. Manholes.
 - 5. Handholes.
 - 6. Cleanouts.

3.3 PENETRATIONS

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
 - 1. Seal penetrations with flashing sealant.
 - 2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 - 3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches (50 mm) below top of roof flashing.
 - 4. Seal jacket to roof flashing with flashing sealant.
- B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.
- C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
 - 1. Seal penetrations with flashing sealant.
 - 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 - 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches (50 mm).
 - 4. Seal jacket to wall flashing with flashing sealant.
- D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
- F. Insulation Installation at Floor Penetrations:
 - 1. Pipe: Install insulation continuously through floor penetrations.
 - 2. Seal penetrations through fire-rated assemblies

3.4 GENERAL PIPE INSULATION INSTALLATION

- A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.
- B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:
 - 1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity, unless otherwise indicated.

2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
 3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
 4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
 5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below ambient services, provide a design that maintains vapor barrier.
 6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
 7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below ambient services and a breather mastic for above ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
 8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
 9. Stencil or label the outside insulation jacket of each union with the word "UNION." Match size and color of pipe labels.
- C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes, vessels, and equipment. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.
- D. Install removable insulation covers at locations indicated. Installation shall conform to the following:
1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
 2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
 3. Construct removable valve insulation covers in same manner as for flanges except divide the two-part section on the vertical center line of valve body.
 4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches

(50 mm) over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.

5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.5 FLEXIBLE ELASTOMERIC INSULATION INSTALLATION

- A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- B. Insulation Installation on Pipe Flanges:
 1. Install pipe insulation to outer diameter of pipe flange.
 2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
 3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
 4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- C. Insulation Installation on Pipe Fittings and Elbows:
 1. Install mitered sections of pipe insulation.
 2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- D. Insulation Installation on Valves and Pipe Specialties:
 1. Install preformed valve covers manufactured of same material as pipe insulation when available.
 2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
 3. Install insulation to flanges as specified for flange insulation application.
 4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.6 MINERAL-FIBER INSULATION INSTALLATION

- A. Insulation Installation on Straight Pipes and Tubes:
 1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
 2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
 3. For insulation with factory-applied jackets on above ambient surfaces, secure laps with outward clinched staples at 6 inches (150 mm) o.c.
 4. For insulation with factory-applied jackets on below ambient surfaces, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.
- B. Insulation Installation on Pipe Flanges:
 1. Install preformed pipe insulation to outer diameter of pipe flange.
 2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.

3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch (25 mm), and seal joints with flashing sealant.
- C. Insulation Installation on Pipe Fittings and Elbows:
 1. Install preformed sections of same material as straight segments of pipe insulation when available.
 2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.
- D. Insulation Installation on Valves and Pipe Specialties:
 1. Install preformed sections of same material as straight segments of pipe insulation when available.
 2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
 3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
 4. Install insulation to flanges as specified for flange insulation application.

3.7 PIPING INSULATION SCHEDULE, GENERAL

- A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.
- B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
 1. Drainage piping located in crawl spaces.
 2. Underground piping.
 3. Chrome-plated pipes and fittings unless there is a potential for personnel injury or for ADA compliance.

3.8 INDOOR PIPING INSULATION SCHEDULE

- A. Domestic Hot and Recirculated Hot Water: Insulation shall be one of the following:
 1. Flexible Elastomeric:
 - a. Pipes 1" and larger 1 inch (25 mm) thick.
 2. Mineral-Fiber, Preformed Pipe Insulation, Type I:
 - a. Pipes 1" and larger 1 inch (25 mm) thick.
- B. Domestic Cold Water (Potable): Insulation shall be one of the following:
 1. Flexible Elastomeric: 1 inch (25 mm)] thick.
 2. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch (25 mm) thick.
- C. Stormwater and Overflow: Insulation shall be one of the following:
 1. Flexible Elastomeric: 1 inch (25 mm) thick.
 2. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch (25 mm) thick.
- D. Roof Drain and Overflow Drain Bodies: Insulation shall be one of the following:
 1. Flexible Elastomeric: 1 inch (25 mm)] thick.
 2. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch (25 mm) thick.

3.9 MECHANICAL ROOM INSULATION AND JACKETING

- A. All piping in mechanical rooms, under 8'0" shall be insulated with cellular glass product, 2" thick with color coded 20 mil PVC jacket. Piping above 8'0 shall comply with sections above.

END OF SECTION 22 07 00

SECTION 22 11 16 - DOMESTIC WATER PIPING (POTABLE)

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. Specialty valves.
 - 2. Flexible connectors.
 - 3. Escutcheons.
 - 4. Sleeves and sleeve seals.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Field quality-control reports.

1.4 QUALITY ASSURANCE

- A. Piping materials shall bear label, stamp, or other markings of specified testing agency.
- B. Comply with NSF 61 for potable domestic water piping and components.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

- A. Type 'M' hard piping for all pipes 1¼" and larger. With brazed joints.
- B. Press fittings will not be accepted.
- C. No galvanized piping or components will be accepted.
- D. Type 'L' copper tubing with brazed joints for all piping 1" and smaller.
- E. DCW piping serving flush valves shall be copper type 'M' piping.
- F. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.
- G. Hard Copper Tube: ASTM B 88, Type L water tube, drawn temper.
 - 1. Wrought-Copper Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.
 - 2. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.
 - 3. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.
- H. Soft Copper Tube: ASTM B 88, Type K water tube, annealed temper.
 - 1. Copper Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.

2.2 PIPING JOINING MATERIALS

- A. Brazed joins and fittings for copper piping.

- B. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick or ASME B16.21, nonmetallic and asbestos free, unless otherwise indicated; full-face or ring type unless otherwise indicated.
- C. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.
- D. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.

2.3 SPECIALTY VALVES

- A. Comply with requirements in Division 22 Section "General-Duty Valves for Plumbing Piping" for general-duty metal valves.
- B. Comply with requirements in Division 22 Section "Domestic Water Piping Specialties" for balancing valves, drain valves, backflow preventers, and vacuum breakers.

2.4 FLEXIBLE CONNECTORS

- A. Bronze-Hose Flexible Connectors: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.
 - 1. Working-Pressure Rating: Minimum 200 psig (1380 kPa).
 - 2. End Connections NPS 2 (DN 50) and Smaller: Threaded copper pipe or plain-end copper tube.
 - 3. End Connections NPS 2-1/2 (DN 65) and Larger: Flanged copper alloy.
- B. Stainless-Steel-Hose Flexible Connectors: Corrugated-stainless-steel tubing with stainless-steel wire-braid covering and ends welded to inner tubing.
 - 1. Working-Pressure Rating: Minimum 200 psig (1380 kPa).
 - 2. End Connections NPS 2 (DN 50) and Smaller: Threaded steel-pipe nipple.
 - 3. End Connections NPS 2-1/2 (DN 65) and Larger: Flanged steel nipple.

2.5 ESCUTCHEONS

- A. General: Manufactured ceiling, floor, and wall escutcheons and floor plates.
- B. One Piece, Cast Brass: Polished, chrome-plated finish with setscrews.
- C. One Piece, Stamped Steel: Chrome-plated finish with setscrew.
- D. Split Casting, Cast Brass: Polished, chrome-plated finish with concealed hinge and setscrew.

2.6 SLEEVES

- A. Cast-Iron Wall Pipes: Fabricated of cast iron, and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.
- B. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc-coated, with plain ends.
- C. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
 - 1. Underdeck Clamp: Clamping ring with setscrews.

2.7 SLEEVE SEALS

- A. Description: Modular sealing element unit, designed for field assembly, used to fill annular space between pipe 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: Stainless steel.
 - 3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements.

2.8 GROUT

- A. Standard: ASTM C 1107, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- B. Characteristics: Non-shrink; recommended for interior and exterior applications.
- C. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of domestic water piping. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- B. Install copper tubing under building slab according to CDA's "Copper Tube Handbook."
- C. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve, inside the building at each domestic water service entrance. Comply with requirements in Division 22 Section "Meters and Gages for Plumbing Piping" for pressure gages and Division 22 Section "Domestic Water Piping Specialties" for drain valves and strainers.
- D. Install shutoff valve immediately upstream of each dielectric fitting.
- E. Install domestic water piping level with 0.25 percent slope downward toward drain and plumb.
- F. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.
- G. 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.
- H. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.
- I. Install piping adjacent to equipment and specialties to allow service and maintenance.
- J. Install piping to permit valve servicing.
- K. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than system pressure rating used in applications below unless otherwise indicated.
- L. Install piping free of sags and bends.
- M. Install fittings for changes in direction and branch connections.
- N. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.

3.2 JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.
- C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.
- D. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" Chapter.

- E. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems. Use bronze nipples or ball valves.

3.3 VALVE INSTALLATION

- A. General-Duty Valves: Comply with requirements in Division 22 Section "General-Duty Valves for Plumbing Piping" for valve installations.
- B. Install shutoff valve close to water main on each branch and riser serving plumbing fixtures or equipment, on each water supply to equipment, and on each water supply to plumbing fixtures that do not have supply stops. Use ball or gate valves for piping NPS 2 (DN 50) and smaller. Use butterfly or gate valves for piping NPS 2-1/2 (DN 65) and larger.
- C. Install drain valves for equipment at base of each water riser, at low points in horizontal piping, and where required to drain water piping.
 - 1. Hose-End Drain Valves: At low points in water mains, risers, and branches.
- D. Install balancing valve in each hot-water circulation return branch and discharge side of each pump and circulator. Set balancing valves partly open to restrict but not stop flow. Use ball valves for piping NPS 2 (DN 50) and smaller. Comply with requirements in Division 22 Section "Domestic Water Piping Specialties" for balancing valves.

3.4 FLEXIBLE CONNECTOR INSTALLATION

- A. Install flexible connectors in suction and discharge piping connections to each domestic water pump.
- B. Install bronze-hose flexible connectors in copper domestic water tubing.

3.5 HANGER AND SUPPORT INSTALLATION

- A. Comply with requirements in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support products and installation.
 - 1. Vertical Piping: MSS Type 8 or 42, clamps.
 - 2. Individual, Straight, Horizontal Piping Runs:
 - a. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.
- B. Support vertical piping and tubing at base.
- C. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 3/4 (DN 20) and Smaller: 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
 - 2. NPS 1 and NPS 1-1/4 (DN 25 and DN 32): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
 - 3. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
 - 4. NPS 3: 108 inches (2700 mm) with 1/2-inch (13-mm) rod.
- D. Install supports for vertical copper tubing every 10 feet (3 m).
- E. Support piping and tubing not listed in this article according to MSS SP-69 and manufacturer's written instructions.

3.6 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to equipment and machines to allow service and maintenance.
- C. Connect domestic water piping to exterior water-service piping. Use transition fitting to join dissimilar piping materials.
- D. Connect domestic water piping to water-service piping with shutoff valve; extend and connect to the following:
 - 1. Water Heaters: Cold-water inlet and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.

2. Plumbing Fixtures: Cold- and hot-water supply piping in sizes indicated, but not smaller than required by plumbing code. Comply with requirements in Division 22 plumbing fixture Sections for connection sizes.
3. Equipment: Cold- and hot-water supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection. Use flanges instead of unions for NPS 2-1/2 (DN 65) and larger.

3.7 ESCUTCHEON INSTALLATION

- A. Install escutcheons for penetrations of walls, ceilings, and floors.
- B. Escutcheons for New Piping:
 1. Piping with Fitting or Sleeve Protruding from Wall: One piece, deep pattern.
 2. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish with set screw.
 3. Bare Piping at Ceiling Penetrations in Finished Spaces: One piece or split casting, cast brass with polished chrome-plated finish with set screw.
 4. Bare Piping in Unfinished Service Spaces: One piece, cast brass with rough-brass finish with set screw.
 5. Bare Piping in Equipment Rooms: One piece, cast brass with set screw.
 6. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece floor plate.

3.8 SLEEVE INSTALLATION

- A. General Requirements: Install sleeves for pipes and tubes passing through penetrations in floors, partitions, roofs, and walls.
- B. Sleeves are not required for core-drilled holes.
- C. Cut sleeves to length for mounting flush with both surfaces unless otherwise indicated.
- D. Install sleeves in new partitions, slabs, and walls as they are built.
- E. For interior wall penetrations, seal annular space between sleeve and pipe or pipe insulation using joint sealants appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants" for joint sealants.
- F. Seal space outside of sleeves in concrete slabs and walls with grout.
- G. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation unless otherwise indicated.
- H. Install sleeve materials according to the following applications:
 1. Sleeves for Piping Passing through Concrete Floor Slabs: Steel pipe.
 2. Sleeves for Piping Passing through Gypsum-Board Partitions:
 - a. Steel pipe sleeves for pipes smaller than NPS 6 (DN 150).
 - b. Exception: Sleeves are not required for water supply tubes and waste pipes for individual plumbing fixtures if escutcheons will cover openings.
- I. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping" for firestop materials and installations.

3.9 SLEEVE SEAL INSTALLATION

- A. Install sleeve seals in sleeves in exterior concrete walls at water-service piping entries into building.
- B. Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble sleeve seal components and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.10 IDENTIFICATION

- A. Identify system components. Comply with requirements in Division 22 Section "Identification for Plumbing Piping and Equipment" for identification materials and installation.
- B. Label pressure piping with system operating pressure.

3.11 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Piping Inspections:
 - 1. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
 - 2. During installation, notify authorities having jurisdiction at least one day before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:
 - a. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
 - b. Final Inspection: Arrange final inspection for authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
 - 3. Re-inspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for re-inspection.
 - 4. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
- C. Piping Tests:
 - 1. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
 - 2. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit a separate report for each test, complete with diagram of portion of piping tested.
 - 3. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
 - 4. Cap and subject piping to static water pressure of 50 psig (345 kPa) above operating pressure, or 100psig whichever is greater, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
 - 5. Repair leaks and defects with new materials and retest piping or portion thereof until satisfactory results are obtained.
 - 6. Prepare reports for tests and for corrective action required.
- D. Domestic water piping will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

3.12 CLEANING

- A. Clean and disinfect potable domestic water piping as follows:
 - 1. Purge new piping before using.
 - 2. Fill Line: After all prerequisites are met, fill the system slowly with water, at a velocity of approximately 1 foot per second, while necessary measures are taken to eliminate all air at the highest points of the system where air may collect in pockets. After filling, shut off system in order to prevent contaminated water from flowing back in the line supplying the water.
 - 3. Pressure Test: A pressure test shall be performed. Piping shall be tested at 1.5 times working pressure for 24 hrs.

4. Flushing: Allow filled system to set undisturbed for a minimum of 24 hours, then begin flushing operations. The section of main to be disinfected shall be flushed through blow-off assemblies. Flushing shall be a velocity of not less than 2.5 feet per second to remove sediment and other foreign matter until the water runs clear. The Contractor shall be responsible for making adequate provisions for drainage of large volume of flushing water, including proper de-chlorination/disposal of chlorinated water. Any damages that may occur from this operation shall be the sole responsibility of the Contractor. In conjunction with beginning flushing, authorities having jurisdiction representative will perform a high range chlorine concentration test. Chlorine concentration of 50 mg/l minimum must be provided. Allow chlorinated water to set in the test section for 24 hours. The chlorine concentration shall not drop below 20 ppm within a minimum period of 24 hours.
5. Sampling – Day 1: Check chlorine and turbidity. After allowing the system to flush so that at least two volumes of water pass through the main, the first bacteria sample shall be collected at regular intervals not exceeding 1,200 feet, and tested for bacteriological quality. The contractor shall be responsible for making adequate provisions for drainage of large volume of flushing water, including proper de-chlorination/disposal of heavily chlorinated water.
6. Sampling – Day 2: The water main shall not be flushed again. Inspector will check both chlorine concentration and turbidity. If within the acceptable limits, a second bacteriological test will be performed collecting from the same discharge points as on day one. If the second bacteria sample has passed, the system shall be left in service, provided a low range chlorine concentration test has been taken and approved by an OWASA representative. The chlorine concentration shall be less than 2 mg/l or no higher than that generally prevailing in the source system.
7. Certification of bacteriological testing for quality of the domestic water shall be conducted prior of and included in the request for Beneficial Occupancy

3.13 PIPING SCHEDULE

- A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.
- B. Flanges and unions may be used for aboveground piping joints unless otherwise indicated.
- C. Under-building-slab, domestic water, building service piping, NPS 3 and smaller, shall be the following:
 1. Soft copper tube, ASTM B 88, Type K; wrought-copper solder-joint fittings; and brazed joints.
 2. Concrete-lined DIP with integral flanges. "Mega Lug" – type fittings will not be accepted.
- D. Aboveground domestic water piping, NPS 1" and smaller except for flush valves shall be the following:
 1. Hard copper tube, ASTM B 88, Type L wrought-copper solder-joint fittings; and soldered joints.
- E. Aboveground domestic water piping, NPS 1¼" and larger and for all flush valves shall be the following:
 1. Hard copper tube, ASTM B 88, Type M copper with brazed joints and fittings.

PART 4 - FINAL

4.1 After Final Flushing, flow all fixtures to confirm the valves are open.

END OF SECTION 22 11 16

SECTION 22 11 19 - DOMESTIC WATER PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following domestic water piping specialties:
 - 1. Vacuum breakers.
 - 2. Backflow preventers.
 - 3. Water pressure-reducing valves.
 - 4. Balancing valves.
 - 5. Hose bibbs.
 - 6. Wall hydrants.
 - 7. Drain valves.
 - 8. Water hammer arresters.
 - 9. Temperature Gages.
 - 10. Recessed valve boxes.
- B. Minimum Working Pressure for Domestic Water Piping Specialties: 125 psig, unless otherwise indicated.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Field quality-control test reports.
- C. Operation and maintenance data.

1.4 QUALITY ASSURANCE

- A. NSF Compliance:
 - 1. Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic domestic water piping components.
 - 2. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9."

PART 2 - PRODUCTS

2.1 VACUUM BREAKERS

- A. Pipe-Applied, Atmospheric-Type Vacuum Breakers
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ames Co.
 - b. Cash Acme.
 - c. Conbraco Industries, Inc.
 - d. FEBCO; SPX Valves & Controls.
 - e. Rain Bird Corporation.
 - f. Toro Company (The); Irrigation Div.
 - g. Watts Industries, Inc.; Water Products Div.

- h. Zurn Plumbing Products Group; Wilkins Div.
 - 2. Standard: ASSE 1001.
 - 3. Size: NPS 1/4 to NPS 3 , as required to match connected piping.
 - 4. Body: Bronze.
 - 5. Inlet and Outlet Connections: Threaded.
 - 6. Finish: Chrome plated.
- B. Hose-Connection Vacuum Breakers
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Arrowhead Brass Products, Inc.
 - b. Cash Acme.
 - c. Conbraco Industries, Inc.
 - d. Legend Valve.
 - e. MIFAB, Inc.
 - f. Prier Products, Inc.
 - g. Watts Industries, Inc.; Water Products Div.
 - h. Woodford Manufacturing Company.
 - i. Zurn Plumbing Products Group; Light Commercial Operation.
 - j. Zurn Plumbing Products Group; Wilkins Div.
 - 2. Standard: ASSE 1001.
 - 3. Body: Bronze, nonremovable, with manual drain.
 - 4. Outlet Connection: Garden-hose threaded complying with ASME B1.20.7.
 - 5. Finish: Chrome or nickel plated

2.2 BACKFLOW PREVENTERS

- A. Reduced-Pressure-Principle Backflow Preventers
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ames Co.
 - b. Conbraco Industries, Inc.
 - c. FEBCO; SPX Valves & Controls.
 - d. Flomatic Corporation.
 - e. Watts Industries, Inc.; Water Products Div.
 - f. Zurn Plumbing Products Group; Wilkins Div.
 - 2. Standard: ASSE 1013.
 - 3. AHJ: Backflow preventer shall comply with the City of Raleigh Backflow prevention guidelines in materials, and installation.
 - 4. Operation: Continuous-pressure applications.
 - 5. Pressure Loss: 12 psig maximum, through middle 1/3 of flow range.
 - 6. Size: see drawings
 - 7. Body: Bronze for NPS 2 and smaller
 - 8. End Connections: Threaded for NPS 2 and smaller
 - 9. Configuration: Designed for horizontal, straight through flow.
 - 10. Accessories:
 - a. Valves: Ball type with threaded ends on inlet and outlet of NPS 2 and smaller;
 - b. Air-Gap Fitting: ASME A112.1.2, matching backflow-preventer connection.
- B. Backflow-Preventer Test Kits
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Conbraco Industries, Inc.
 - b. FEBCO; SPX Valves & Controls.
 - c. Flomatic Corporation.
 - d. Watts Industries, Inc.; Water Products Div.

- e. Zurn Plumbing Products Group; Wilkins Div.
2. Description: Factory calibrated, with gages, fittings, hoses, and carrying case with test-procedure instructions.

2.3 WATER PRESSURE-REDUCING VALVES

A. Water Regulators

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Cash Acme.
 - b. Conbraco Industries, Inc.
 - c. Honeywell Water Controls.
 - d. Watts Industries, Inc.; Water Products Div.
 - e. Zurn Plumbing Products Group; Wilkins Div.
2. Standard: ASSE 1003.
3. Pressure Rating: Initial working pressure of 150 psig
4. Design Inlet Pressure: To be measured by the contractor
5. Design Outlet Pressure Setting: 80 psig
6. Body: Bronze for NPS 2 and smaller

2.4 BALANCING VALVES

A. Memory-Stop Balancing Valves

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Conbraco Industries, Inc.
 - b. Crane Co.; Crane Valve Group; Crane Valves.
 - c. Crane Co.; Crane Valve Group; Jenkins Valves.
 - d. Crane Co.; Crane Valve Group; Stockham Div.
 - e. Hammond Valve.
 - f. Milwaukee Valve Company.
 - g. NIBCO INC.
 - h. Red-White Valve Corp.
2. Standard: MSS SP-110 for two-piece, copper-alloy ball valves.
3. Pressure Rating: 400-psig minimum CWP.
4. Size: NPS 2 or smaller.
5. Body: Copper alloy.
6. Port: full port.
7. Ball: Chrome-plated brass.
8. Seats and Seals: Replaceable.
9. End Connections: Solder joint or threaded.
10. Handle: Vinyl-covered steel with memory-setting device.

2.5 HOSE BIBBS

A. Hose Bibbs:

1. Standard: ASME A112.18.1 for sediment faucets.
2. Body Material: Bronze.
3. Seat: Bronze, replaceable.
4. Supply Connections: NPS 1/2 or NPS 3/4 threaded or solder-joint inlet.
5. Outlet Connection: Garden-hose thread complying with ASME B1.20.7.
6. Pressure Rating: 125 psig (860 kPa).
7. Vacuum Breaker: Integral or field-installation, nonremovable, drainable, hose-connection vacuum breaker complying with ASSE 1011.
8. Finish for Equipment Rooms: Rough bronze, or chrome or nickel plated.
9. Finish for Finished Rooms and pool area: Chrome or nickel plated.
10. Operation for Equipment Rooms: Wheel handle

11. Operation for Finished Rooms: Wheel handle
12. Include operating key with each operating-key hose bibb.
13. Include integral wall flange with each chrome- or nickel-plated hose bibb.

2.6 WALL HYDRANTS

A. Nonfreeze Wall Hydrants:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company.
 - b. MIFAB, Inc.
 - c. Prier Products, Inc.
 - d. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - e. Tyler Pipe; Wade Div.
 - f. Watts Drainage Products Inc.
 - g. Woodford Manufacturing Company.
 - h. Zurn Plumbing Products Group; Light Commercial Operation.
 - i. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.21.3M for concealed -outlet, self-draining wall hydrants.
3. Pressure Rating: 125 psig.
4. Operation: Loose key.
5. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
6. Inlet: NPS 3/4.
7. Outlet: Concealed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
8. Box: Deep, flush mounting with cover.
9. Box and Cover Finish: Polished nickel bronze.
10. Outlet: Exposed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.

2.7 DRAIN VALVES

A. Ball-Valve-Type, Hose-End Drain Valves :

1. Standard: MSS SP-110 for standard-port, two-piece ball valves.
2. Pressure Rating: 400-psig minimum CWP.
3. Size: NPS 3/4 .
4. Body: Copper alloy.
5. Ball: Chrome-plated brass.
6. Seats and Seals: Replaceable.
7. Handle: Vinyl-covered steel.
8. Inlet: Threaded or solder joint.
9. Outlet: Threaded, short nipple with garden-hose thread complying with ASME B1.20.7 and cap with brass chain.

2.8 WATER HAMMER ARRESTERS

A. Water Hammer Arresters:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AMTROL, Inc.
 - b. Josam Company.
 - c. MIFAB, Inc.
 - d. PPP Inc.
 - e. Sioux Chief Manufacturing Company, Inc.
 - f. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - g. Tyler Pipe; Wade Div.

- h. Watts Drainage Products Inc.
 - i. Zurn Plumbing Products Group; Specification Drainage Operation.
 - 2. Standard: ASSE 1010 or PDI-WH 201.
 - 3. Type: Copper tube with piston.
 - 4. Size: ASSE 1010, Sizes AA and A through F or PDI-WH 201, Sizes A through F.

2.9 TEMPERATURE GAGES

- A. Digital temperature gages:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AMTROL, Inc.
 - b. Josam Company.
 - c. MIFAB, Inc.
 - d. PPP Inc.
 - e. Sioux Chief Manufacturing Company, Inc.
 - f. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - g. Tyler Pipe; Wade Div.
 - h. Watts Drainage Products Inc.
 - i. Zurn Plumbing Products Group; Specification Drainage Operation.
 - 2. Display: Digital, LCD, 1"
 - 3. Case: Polycarbonate or Aluminum.
 - 4. Power: Solar/Battery
 - 5. Power Life: 4000hrs.
 - 6. Automatic power off: 1 hour
 - 7. Connector: Adjustable type, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device.
 - 8. Stem: Copper-plated steel, aluminum, or brass for thermowell installation and of length to suit installation.
 - 9. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

2.10 RECESSED VALVE BOXES

- A. Fully enclosed.
- B. 16 gauge galvanized steel with prime coat.
- C. One-piece frame.
- D. 1" flange.
- E. Screwdriver actuated latch.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Refer to Division 22 Section "Common Work Results for Plumbing" for piping joining materials, joint construction, and basic installation requirements.
- B. Install backflow preventers in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction.
 - 1. Locate backflow preventers in same room as connected equipment or system.
 - 2. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe to floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are not acceptable for this application.

3. Do not install bypass piping around backflow preventers.
- C. Install water regulators with inlet and outlet shutoff valves and bypass with memory-stop balancing valve. Install pressure gages on inlet and outlet.
- D. Install balancing valves in locations where they can easily be adjusted.
- E. Install temperature-actuated water mixing valves with check stops or shutoff valves on inlets and with shutoff valve on outlet.
 1. Install thermometers and water regulators if specified.
- F. Install water hammer arresters in water piping according to PDI-WH 201.
- G. Install supply-type, trap-seal primer valves with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting. Adjust valve for proper flow.
- H. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping and specialties.
- I. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:
 1. Reduced-pressure-principle backflow preventers.
 2. Double-check backflow-prevention assemblies.
 3. Water pressure-reducing valves.
- J. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Division 22 Section "Identification for Plumbing Piping and Equipment."

3.2 FIELD QUALITY CONTROL

- A. Perform the following tests and prepare test reports:
 1. Test each reduced-pressure-principle backflow preventer double-check backflow-prevention assembly according to authorities having jurisdiction and the device's reference standard.
- B. Remove and replace malfunctioning domestic water piping specialties and retest as specified above.

3.3 ADJUSTING

- A. Set field-adjustable pressure set points of water pressure-reducing valves.
- B. Set field-adjustable flow of balancing valves.
- C. Set field-adjustable temperature set points of temperature-actuated water mixing valves.

END OF SECTION 22 11 19

SECTION 22 11 23 - DOMESTIC WATER PUMPS**PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

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

1.2 SUMMARY

- A. This Section includes the following all-bronze and bronze-fitted centrifugal pumps for domestic cold- and hot-water circulation:
 - 1. Close-coupled, in-line, sealless centrifugal pumps.

1.3 SUBMITTALS

- A. Product Data: For each type and size of domestic water pump specified. Include certified performance curves with operating points plotted on curves; and rated capacities of selected models, furnished specialties, and accessories.
- B. Shop Drawings: Diagram power, signal, and control wiring.
- C. Operation and maintenance data.

1.4 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. UL Compliance: Comply with UL 778 for motor-operated water pumps.

PART 2 - PRODUCTS**2.1 MANUFACTURERS**

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
 - 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.

2.2 CLOSE-COUPLED, IN-LINE, SEALLESS CENTRIFUGAL PUMPS

- A. Manufacturers:
 - 1. Armstrong Pumps Inc.
 - 2. Bell & Gossett Domestic Pump; ITT Industries.
 - 3. Grundfos Pumps Corp.
 - 4. Taco, Inc.
- B. Description: Factory-assembled and -tested, single-stage, close-coupled, in-line, sealless centrifugal pumps as defined in HI 5.1-5.6.
 - 1. Pump and Motor Assembly: Hermetically sealed, replaceable-cartridge-type unit with motor and impeller on common shaft and designed for installation with pump and motor shaft mounted horizontally.
 - 2. Casing: Bronze, with threaded companion-flange connections.
 - 3. Impeller: Corrosion-resistant material.

4. Motor: Single speed, unless otherwise indicated. Comply with requirements in Division 22 Section "Common Motor Requirements for Plumbing Equipment."

2.3 FLEXIBLE CONNECTORS

- A. Description: Corrugated, bronze inner tubing covered with stainless steel wire braid. Include copper-tube ends or bronze flanged ends, braze-welded to tubing. Include 125-psig (860-kPa) minimum working-pressure rating and ends matching pump connections.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with HI 1.4.
- B. Install pumps with access for periodic maintenance including removal of motors, impellers, couplings, and accessories.
- C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.
- D. Install in-line, sealless centrifugal pumps with motor and pump shafts horizontal.
- E. Install continuous-thread hanger rods and elastomeric hangers of sufficient size Mechanical Vibration to support pump weight. Vibration isolation devices are specified in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment." Fabricate brackets or supports as required. Hanger and support materials are specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."
- F. Install immersion-type thermostats in hot-water return piping.
- G. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- H. Install piping adjacent to pumps to allow service and maintenance.
- I. Connect domestic water piping to pumps. Install suction and discharge piping equal to or greater than size of pump nozzles. Refer to Division 22 Section "Domestic Water Piping."
 1. Install flexible connectors adjacent to pumps in suction and discharge piping of close-coupled, horizontally mounted, in-line centrifugal pumps.
 2. Install shutoff valve and strainer on suction side of pumps, and check valve and throttling valve on discharge side of pumps. Install valves same size as connected piping. Refer to Division 22 Section "General-Duty Valves for Plumbing Piping" for general-duty valves for domestic water piping and Division 22 Section "Domestic Water Piping Specialties" for strainers.
 3. Install pressure gages at suction and discharge of pumps. Install at integral pressure-gage tapings where provided or install pressure-gage connectors in suction and discharge piping around pumps. Refer to Division 22 Section "Meters and Gages for Plumbing Piping" for pressure gages and gage connectors.
- J. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- K. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- L. Interlock pump with water heater burner and time delay relay.

END OF SECTION 22 11 23

SECTION 22 11 24 - FACILITY NATURAL-GAS PIPING**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. Pipes, tubes, and fittings.
 - 2. Piping specialties.
 - 3. Piping and tubing joining materials.
 - 4. Valves.
 - 5. Pressure regulators.
 - 6. Mechanical sleeve seals.
 - 7. Grout.

1.3 DEFINITIONS

- A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspace, and tunnels.
- B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
- C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

1.4 SUBMITTALS

- A. Product Data: For each type of the following:
 - 1. Piping specialties.
 - 2. Corrugated, stainless-steel tubing with associated components.
 - 3. Valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.
 - 4. Pressure regulators. Indicate pressure ratings and capacities.
 - 5. Mechanical sleeve seals.
 - 6. Escutcheons.
- B. Coordination Drawings: Plans and details, drawn to scale, on which natural-gas piping is shown and coordinated with other installations, using input from installers of the items involved.
- C. Site Survey: Plans, drawn to scale, on which natural-gas piping is shown and coordinated with other services and utilities.
- D. Qualification Data: For qualified professional engineer.
- E. Welding certificates.
- F. Field quality-control reports.
- G. Operation and Maintenance Data: For pressure regulators to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

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

- B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.
- 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.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Handling Flammable Liquids: Remove and dispose of liquids from existing natural-gas piping according to requirements of authorities having jurisdiction.
- B. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.
- C. Store and handle pipes and tubes having factory-applied protective coatings to avoid damaging coating, and protect from direct sunlight.
- D. Protect stored PE pipes and valves from direct sunlight.

1.7 PROJECT CONDITIONS

- A. Perform site survey, research public utility records, and verify existing utility locations. Contact utility-locating service for area where Project is located.
- B. Building is classified a seismic design category B and no gas piping seismic design is required.

1.8 COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided.
- B. Coordinate requirements for access panels and doors for valves installed concealed behind finished surfaces. Comply with requirements in Division 08 Section "Access Doors and Frames."

PART 2 - PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

- A. Steel Pipe: ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.
 - 1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
 - 2. Wrought-Steel Welding Fittings: ASTM A 234/A 234M for butt welding and socket welding.
 - 3. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
 - 4. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
 - a. Material Group: 1.1.
 - b. End Connections: Threaded or butt welding to match pipe.
 - c. Lapped Face: Not permitted underground.
 - d. Gasket Materials: ASME B16.20, metallic, flat, asbestos free, aluminum o-rings, and spiral-wound metal gaskets.
 - e. Bolts and Nuts: ASME B18.2.1, carbon steel aboveground and stainless steel underground.
 - 5. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.
 - a. Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.
 - 6. Mechanical Couplings:

- a. Steel flanges and tube with epoxy finish.
- b. Buna-nitrile seals.
- c. Steel bolts, washers, and nuts.
- d. Coupling shall be capable of joining PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.
- e. Steel body couplings installed underground on plastic pipe shall be factory equipped with anode.

2.2 PIPING SPECIALTIES

- A. Appliance Flexible Connectors:
 1. Indoor, Fixed-Appliance Flexible Connectors: Comply with ANSI Z21.24.
 2. Indoor, Movable-Appliance Flexible Connectors: Comply with ANSI Z21.69.
 3. Outdoor, Appliance Flexible Connectors: Comply with ANSI Z21.75.
 4. Corrugated stainless-steel tubing with polymer coating.
 5. Operating-Pressure Rating: 0.5 psig (3.45 kPa).
 6. End Fittings: Zinc-coated steel.
 7. Threaded Ends: Comply with ASME B1.20.1.
 8. Maximum Length: 72 inches (1830 mm).
- B. Quick-Disconnect Devices: Comply with ANSI Z21.41.
 1. Copper-alloy convenience outlet and matching plug connector.
 2. Nitrile seals.
 3. Hand operated with automatic shutoff when disconnected.
 4. For indoor or outdoor applications.
 5. Adjustable, retractable restraining cable.
- C. Y-Pattern Strainers:
 1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
 2. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
 3. Strainer Screen: 40 mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
 4. CWP Rating: 125 psig (862 kPa).
- D. Weatherproof Vent Cap: Cast- or malleable-iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.

2.3 JOINING MATERIALS

- A. Joint Compound and Tape: Suitable for natural gas.
- B. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- C. Brazing Filler Metals: Alloy with melting point greater than 1000 deg F (540 deg C) complying with AWS A5.8/A5.8M. Brazing alloys containing more than 0.05 percent phosphorus are prohibited.

2.4 MANUAL GAS SHUTOFF VALVES

- A. General Requirements for Metallic Valves, NPS 2 (DN 50) and Smaller: Comply with ASME B16.33.
 1. CWP Rating: 125 psig (862 kPa).
 2. Threaded Ends: Comply with ASME B1.20.1.
 3. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
 4. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.

5. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch (25 mm) and smaller.
6. Service Mark: Valves 1-1/4 inches (32 mm) to NPS 2 (DN 50) shall have initials "WOG" permanently marked on valve body.
- B. General Requirements for Metallic Valves, NPS 2-1/2 (DN 65) and Larger: Comply with ASME B16.38.
 1. CWP Rating: 125 psig (862 kPa).
 2. Flanged Ends: Comply with ASME B16.5 for steel flanges.
 3. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
 4. Service Mark: Initials "WOG" shall be permanently marked on valve body.
- C. One-Piece, Bronze Ball Valve with Bronze Trim: MSS SP-110.
 1. Body: Bronze, complying with ASTM B 584.
 2. Ball: Chrome-plated brass.
 3. Stem: Bronze; blowout proof.
 4. Seats: Reinforced TFE; blowout proof.
 5. Packing: Separate packnut with adjustable-stem packing threaded ends.
 6. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
 7. CWP Rating: 600 psig (4140 kPa).
 8. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
 9. Service: Suitable for natural-gas service with "WOG" indicated on valve body.
- D. Bronze Plug Valves: MSS SP-78.
 1. Body: Bronze, complying with ASTM B 584.
 2. Plug: Bronze.
 3. Ends: Threaded, socket, or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
 4. Operator: Square head or lug type with tamperproof feature where indicated.
 5. Pressure Class: 125 psig (862 kPa).
 6. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
 7. Service: Suitable for natural-gas service with "WOG" indicated on valve body.
- E. Valve Boxes:
 1. Cast-iron, two-section box.
 2. Top section with cover with "GAS" lettering.
 3. Bottom section with base to fit over valve and barrel a minimum of 5 inches (125 mm) in diameter.
 4. Adjustable cast-iron extensions of length required for depth of bury.
 5. Include tee-handle, steel operating wrench with socket end fitting valve nut or flat head, and with stem of length required to operate valve.

2.5 MOTORIZED GAS VALVES

- A. Automatic Gas Valves: Comply with ANSI Z21.21.
 1. Body: Brass or aluminum.
 2. Seats and Disc: Nitrile rubber.
 3. Springs and Valve Trim: Stainless steel.
 4. Normally closed.
 5. Visual position indicator.
 6. Electrical operator for actuation by appliance automatic shutoff device.
- B. Electrically Operated Valves: Comply with UL 429.
 1. Pilot operated.

2. Body: Brass or aluminum.
3. Seats and Disc: Nitrile rubber.
4. Springs and Valve Trim: Stainless steel.
5. 120-V ac, 60 Hz, Class B, continuous-duty molded coil, and replaceable.
6. NEMA ICS 6, Type 4, coil enclosure.
7. Normally closed.
8. Visual position indicator.

2.6 PRESSURE REGULATORS

- A. General Requirements:
 1. Single stage and suitable for natural gas.
 2. Steel jacket and corrosion-resistant components.
 3. Elevation compensator.
 4. End Connections: Threaded for regulators NPS 2 (DN 50) and smaller; flanged for regulators NPS 2-1/2 (DN 65) and larger.
- B. Service Pressure Regulators: Comply with ANSI Z21.80.
 1. Body and Diaphragm Case: Cast iron or die-cast aluminum.
 2. Springs: Zinc-plated steel; interchangeable.
 3. Diaphragm Plate: Zinc-plated steel.
 4. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
 5. Orifice: Aluminum; interchangeable.
 6. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
 7. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
 8. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
 9. Overpressure Protection Device: Factory mounted on pressure regulator.
 10. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
 11. Maximum Inlet Pressure: 100 psig (690 kPa)
- C. Line Pressure Regulators: Comply with ANSI Z21.80.
 1. Body and Diaphragm Case: Cast iron or die-cast aluminum.
 2. Springs: Zinc-plated steel; interchangeable.
 3. Diaphragm Plate: Zinc-plated steel.
 4. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
 5. Orifice: Aluminum; interchangeable.
 6. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
 7. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
 8. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
 9. Overpressure Protection Device: Factory mounted on pressure regulator.
 10. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
 11. Maximum Inlet Pressure: 2 psig (13.8 kPa).
- D. Appliance Pressure Regulators: Comply with ANSI Z21.18.
 1. Body and Diaphragm Case: Die-cast aluminum.
 2. Springs: Zinc-plated steel; interchangeable.
 3. Diaphragm Plate: Zinc-plated steel.
 4. Seat Disc: Nitrile rubber.
 5. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.

6. Factory-Applied Finish: Minimum three-layer polyester and polyurethane paint finish.
7. Regulator may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction.
8. Maximum Inlet Pressure: 2 psig (13.8 kPa).

2.7 SLEEVES

- A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
- B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

2.8 MECHANICAL SLEEVE SEALS

- A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
 1. Sealing Elements: EPDM> interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe and sleeve.
 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. Include one nut and bolt for each sealing element.

2.9 LABELING AND IDENTIFYING

- A. Detectable Warning Tape: Acid- and alkali-resistant, PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches (150 mm) wide and 4 mils (0.1 mm) thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches (750 mm) deep; colored yellow.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in for natural-gas piping system to verify actual locations of piping connections before equipment installation.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Inspect natural-gas piping according to NFPA 54 to determine that natural-gas utilization devices are turned off in piping section affected.
- B. Comply with NFPA 54 requirements for prevention of accidental ignition.

3.3 OUTDOOR PIPING INSTALLATION

- A. Comply with NFPA 54 for installation and purging of natural-gas piping.
- B. Install underground, natural-gas piping buried at least 36 inches (900 mm) below finished grade. Comply with requirements in Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.
 1. If natural-gas piping is installed less than 36 inches (900 mm) below finished grade, install it in containment conduit.
- C. Install underground, PE, natural-gas piping according to ASTM D 2774.
- D. Steel Piping with Protective Coating:

1. Apply joint cover kits to pipe after joining to cover, seal, and protect joints.
 2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.
 3. Replace pipe having damaged PE coating with new pipe.
- E. Install fittings for changes in direction and branch connections.
- F. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using 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.
1. Install steel pipe for sleeves smaller than 6 inches (150 mm) in diameter.
- G. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using 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.
- H. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
- I. Install pressure gage upstream and downstream from each service regulator. Pressure gages are specified in Division 23 Section "Meters and Gages for HVAC Piping."

3.4 INDOOR PIPING INSTALLATION

- A. Comply with NFPA 54 for installation and purging of natural-gas piping.
- B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- C. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.
- D. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- E. 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.
- F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- G. Locate valves for easy access.
- H. Install natural-gas piping at uniform grade of 2 percent down toward drip and sediment traps.
- I. Install piping free of sags and bends.
- J. Install fittings for changes in direction and branch connections.
- K. Install escutcheons at penetrations of interior walls, ceilings, and floors.
1. New Piping:
 - a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
 - b. Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
 - c. Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.
- L. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping."
- M. Verify final equipment locations for roughing-in.
- N. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.

- O. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.
 - 1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches (75 mm) long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.
- P. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.
- Q. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels unless indicated to be exposed to view.
- R. Concealed Location Installations: Except as specified below, install concealed natural-gas piping and piping installed under the building in containment conduit constructed of steel pipe with welded joints as described in Part 2. Install a vent pipe from containment conduit to outdoors and terminate with weatherproof vent cap.
 - 1. Above Accessible Ceilings: Natural-gas piping, fittings, valves, and regulators may be installed in accessible spaces without containment conduit.
 - 2. In Floors: Install natural-gas piping with welded or brazed joints and protective coating in cast-in-place concrete floors. Cover piping to be cast in concrete slabs with minimum of 1-1/2 inches (38 mm) of concrete. Piping may not be in physical contact with other metallic structures such as reinforcing rods or electrically neutral conductors. Do not embed piping in concrete slabs containing quick-set additives or cinder aggregate.
 - 3. In Floor Channels: Install natural-gas piping in floor channels. Channels must have cover and be open to space above cover for ventilation.
 - 4. In Walls or Partitions: Protect tubing installed inside partitions or hollow walls from physical damage using steel striker barriers at rigid supports.
 - a. Exception: Tubing passing through partitions or walls does not require striker barriers.
 - 5. Prohibited Locations:
 - a. Do not install natural-gas piping in or through circulating air ducts, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.
 - b. Do not install natural-gas piping in solid walls or partitions.
- S. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.
- T. Connect branch piping from top or side of horizontal piping.
- U. Install unions in pipes NPS 2 (DN 50) and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections. Do not use natural-gas piping as grounding electrode.
- V. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.
- X. Install pressure gage upstream and downstream from each line regulator. Pressure gages are specified in Division 23 Section "Meters and Gages for HVAC Piping."

3.5 VALVE INSTALLATION

- A. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless-steel tubing, aluminum, or copper connector.
- B. Install underground valves with valve boxes.
- C. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.
- D. Install earthquake valves aboveground outside buildings according to listing.
- E. Install anode for metallic valves in underground PE piping.

3.6 PIPING 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. Threaded Joints:
 - 1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
 - 2. Cut threads full and clean using sharp dies.
 - 3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
 - 4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
 - 5. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- D. Welded Joints:
 - 1. Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators.
 - 2. Bevel plain ends of steel pipe.
 - 3. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.

3.7 CONNECTIONS

- A. Connect to utility's gas main according to utility's procedures and requirements.
- B. Install natural-gas piping electrically continuous, and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.
- C. Install piping adjacent to appliances to allow service and maintenance of appliances.
- D. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches (1800 mm) of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.
- E. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

3.8 LABELING AND IDENTIFYING

- A. Comply with requirements in Division 23 Section "Identification for HVAC Piping and Equipment" for piping and valve identification.
- B. Install detectable warning tape directly above gas piping, 12 inches (300 mm) below finished grade, except 6 inches (150 mm) below subgrade under pavements and slabs.

3.9 PAINTING

- A. Paint exposed, exterior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components, with factory-applied paint or protective coating.
 - 1. Alkyd System: MPI EXT 5.1D.
 - a. Prime Coat: Alkyd anticorrosive metal primer.
 - b. Intermediate Coat: Exterior alkyd enamel matching topcoat.
 - c. Topcoat: Exterior alkyd enamel flat.
 - d. Color: Gray.
- B. Paint exposed, interior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components, with factory-applied paint or protective coating.
 - 1. Latex Over Alkyd Primer System: MPI INT 5.1Q.
 - a. Prime Coat: Alkyd anticorrosive metal primer.
 - b. Intermediate Coat: Interior latex matching topcoat.

- c. Topcoat: Interior latex semigloss.
 - d. Color: Yellow.
- C. Damage and Touchup: Repair marred and damaged factory-applied finishes with materials and by procedures to match original factory finish.

3.10 CONCRETE BASES

- A. Concrete Bases: Anchor equipment to concrete base.
 - 1. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger in both directions than supported unit.
 - 2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of the base.
 - 3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
 - 4. Place and secure anchorage devices. Use supported equipment manufacturer's 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.

3.11 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. Test, inspect, and purge natural gas according to NFPA 54 and authorities having jurisdiction.
- C. Natural-gas piping will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

3.12 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain earthquake valves.

3.13 OUTDOOR PIPING SCHEDULE

- A. Underground natural-gas piping shall be:
 - 1. Steel pipe with wrought-steel fittings and welded joints, or mechanical couplings. Coat pipe and fittings with protective coating for steel piping.
- B. Aboveground natural-gas piping shall be one of the following:
 - 1. Steel pipe with malleable-iron fittings and threaded joints.
 - 2. Steel pipe with wrought-steel fittings and welded joints.
- C. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.

3.14 INDOOR PIPING SCHEDULE

- A. Aboveground, branch piping NPS 1 (DN 25) and smaller shall be the following:
 - 1. Steel pipe with malleable-iron fittings and threaded joints.
- B. Aboveground, distribution piping shall be one of the following:
 - 1. Steel pipe with malleable-iron fittings and threaded joints.
 - 2. Steel pipe with steel welding fittings and welded joints.
- C. Underground, below building, piping shall be one of the following:
 - 1. Steel pipe with malleable-iron fittings and threaded joints.
 - 2. Steel pipe with wrought-steel fittings and welded joints.
- D. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat underground pipe and fittings with protective coating for steel piping.

- E. Containment Conduit Vent Piping: Steel pipe with malleable-iron fittings and threaded or wrought-steel fittings with welded joints. Coat underground pipe and fittings with protective coating for steel piping.

3.15 UNDERGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

- A. Connections to Existing Gas Piping: Use valve and fitting assemblies made for tapping utility's gas mains and listed by an NRTL.
- B. Underground:
 - 1. NPS 2 (DN 50) and Smaller: Bronze plug valves.

3.16 ABOVEGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

- A. Valves for pipe sizes NPS 2 (DN 50) and smaller at service meter shall be the following:
 - 1. One-piece, bronze ball valve with bronze trim.
- B. Distribution piping valves for pipe sizes NPS 2 (DN 50) and smaller shall be the following:
 - 1. One-piece, bronze ball valve with bronze trim.

END OF SECTION 22 11 24

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SECTION 22 13 16 - SANITARY WASTE, VENT AND STORM DRAIN PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following soil and waste, storm drainage and vent piping inside the building:
 - 1. Pipe, tube, and fittings.
 - 2. Special pipe fittings.

1.3 PERFORMANCE REQUIREMENTS

- A. Components and installation shall be capable of withstanding the following minimum working pressure, unless otherwise indicated:
 - 1. Soil, Waste, and Vent Piping: 10-foot head of water.

1.4 SUBMITTALS

- A. Field quality-control inspection and test reports.

1.5 QUALITY ASSURANCE

- A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

- A. Hub-and-Spigot Underground
 - 1. Cast-Iron Pipe and Fittings: ASTM A 74, Service class.
 - 2. Gaskets: ASTM C 564, rubber.
- B. Hubless Cast Iron - Aboveground
 - 1. Pipe and Fittings: ASTM A 888 or CISPI 301.
 - 2. Single-Stack Aerator Fittings: ASME B16.45, hubless, cast-iron aerator and deaerator drainage fittings.
 - 3. Heavy-Duty, Hubless-Piping Couplings:
 - a. Standards: ASTM C 1277 and ASTM C 1540.
 - b. Description: Stainless-steel shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

- A. Special pipe fittings with pressure ratings at least equal to piping pressure ratings may be used in applications below, unless otherwise indicated.
- B. Above ground Waste, Vent piping
 - 1. Hub and Spigot Schedule 40 Cast Iron.
- C. Roof leader and storm piping shall be
 - 1. Hub and Spigot Schedule 40 Cast Iron.
- D. Underground, storm drain, soil, waste, and vent piping NPS 5 (DN 125) and smaller shall be the following:
 - 1. Hub and Spigot Schedule 40 Cast Iron.

3.2 PIPING INSTALLATION

- A. Basic piping installation requirements are specified in Division 22 Section "Common Work Results for Plumbing."
- B. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers.
- C. Install wall penetration system at each service pipe penetration through foundation wall. Make installation watertight. Wall penetration systems are specified in Division 22 Section "Common Work Results for Plumbing."
- D. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Use long-turn, double Y-branch and 1/8-bend fittings if 2 fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.
- E. Lay buried building drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.
- F. Install soil and waste drainage and vent piping at the following minimum slopes, unless otherwise indicated:
 - 1. Building Sanitary Drain: 2 percent downward in direction of flow for piping NPS 3 (DN 80) and smaller; 1 percent downward in direction of flow for piping NPS 4 (DN 100) and larger.
 - 2. Horizontal Sanitary Drainage Piping: 2 percent downward in direction of flow.
 - 3. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.
- G. Sleeves are not required for cast-iron soil piping passing through concrete slabs-on-grade if slab is without membrane waterproofing.
- H. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.
- I. Do not locate any clean outs above ceilings, clean outs must be brought level to the floor above.

3.3 JOINT CONSTRUCTION

- A. Basic piping joint construction requirements are specified in Division 22 Section "Common Work Results for Plumbing."

3.4 HANGER AND SUPPORT INSTALLATION

- A. Pipe hangers and supports are specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment." Install the following:
 - 1. Vertical Piping: MSS Type 8 or Type 42, clamps.
 - 2. Individual, Straight, Horizontal Piping Runs: According to the following:

- a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
- B. Install supports according to Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."
- C. Support vertical piping and tubing at base and at each floor.
- D. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch (10-mm) minimum rods.
- E. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.5 CONNECTIONS

- A. Connect drainage and vent piping to the following:
 - 1. Plumbing Fixtures: Connect drainage piping in sizes indicated, but not smaller than required by plumbing code. Refer to Division 22 Section "Sanitary Waste Piping Specialties".
 - 2. Plumbing Specialties: Connect drainage and vent piping in sizes indicated, but not smaller than required by plumbing code. Refer to Division 22 Section "Sanitary Waste Piping Specialties."
 - 3. Equipment: Connect drainage piping as indicated. Provide shutoff valve, if indicated, and union for each connection. Use flanges instead of unions for connections NPS 2-1/2 (DN 65) and larger.

3.6 FIELD QUALITY CONTROL

- A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
 - 1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
 - 2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
- B. Re-inspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for re-inspection.
- C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
- D. Test sanitary drainage and vent piping accordance with North Carolina Plumbing Code.
 - 1. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
 - 2. Prepare reports for tests and required corrective action.

3.7 CLEANING

- A. Clean interior of piping. Remove dirt and debris as work progresses.
- B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.
- C. Place plugs in ends of uncompleted piping at end of day and when work stops.

END OF SECTION 22 13 16

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SECTION 22 13 19 - SANITARY WASTE PIPING SPECIALTIES**PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

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

1.2 SUMMARY

- A. This Section includes the following sanitary drainage piping specialties:
 - 1. Cleanouts.
 - 2. Floor drains.
 - 3. Miscellaneous sanitary drainage piping specialties.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and accessories for grease interceptors.

1.4 QUALITY ASSURANCE

- A. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.

PART 2 - PRODUCTS**2.1 CLEANOUTS**

- A. Exposed Cast-Iron Cleanouts :
 - 1. 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:
 - a. Josam Company; Josam Div.
 - b. MIFAB, Inc.
 - c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - d. Tyler Pipe; Wade Div.
 - e. Watts Drainage Products Inc.
 - f. Zurn Plumbing Products Group; Specification Drainage Operation.
 - 2. Standard: ASME A112.36.2M for cast iron for cleanout test tee.
 - 3. Size: Same as connected drainage piping
 - 4. Body Material: Hubless, cast-iron soil pipe test tee as required to match connected piping.
 - 5. Closure: Countersunk or raised-head, brass plug.
 - 6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
- B. Cast-Iron Floor Cleanouts ; FCO:
 - 1. 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:
 - a. Josam Company; Josam Div.
 - b. Oatey.

- c. Sioux Chief Manufacturing Company, Inc.
 - d. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - e. Tyler Pipe; Wade Div.
 - f. Watts Drainage Products Inc.
 - g. Zurn Plumbing Products Group; Light Commercial Operation.
 - h. Zurn Plumbing Products Group; Specification Drainage Operation.
 - 2. Standard: ASME A112.36.2M for threaded, adjustable housing cleanout.
 - 3. Size: Same as connected branch.
 - 4. Type: Cast-iron soil pipe with cast-iron ferrule, threaded, adjustable housing.
 - 5. Body or Ferrule: Cast iron
 - 6. Clamping Device: Not required].
 - 7. Outlet Connection: Inside calk.
 - 8. Closure: Brass plug with tapered threads.
 - 9. Adjustable Housing Material: Cast iron with threads.
 - 10. Frame and Cover Material and Finish: Nickel-bronze, copper alloy.
 - 11. Frame and Cover Shape: Round
 - 12. Top Loading Classification: Heavy Duty.
 - 13. Riser: ASTM A 74, Service class, cast-iron drainage pipe fitting and riser to cleanout.
- C. Cast-Iron Wall Cleanouts; (WCO):
- 1. 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:
 - a. Josam Company; Josam Div.
 - b. MIFAB, Inc.
 - c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - d. Tyler Pipe; Wade Div.
 - e. Watts Drainage Products Inc.
 - f. Zurn Plumbing Products Group; Specification Drainage Operation.
 - 2. Standard: ASME A112.36.2M. Include wall access.
 - 3. Size: Same as connected drainage piping.
 - 4. Body: Hubless, cast-iron soil pipe test tee as required to match connected piping.
 - 5. Closure: Countersunk or raised-head, drilled-and-threaded brass plug.
 - 6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
 - 7. Wall Access: Round, flat, chrome-plated brass or stainless-steel cover plate with screw.

2.2 FLOOR DRAINS

- A. Cast-Iron Floor Drains : (Refer to Drawing schedule for drain types):
- 1. 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:
 - a. Commercial Enameling Co.
 - b. Josam Company; Josam Div.
 - c. MIFAB, Inc.
 - d. Prier Products, Inc.
 - e. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - f. Tyler Pipe; Wade Div.
 - g. Watts Drainage Products Inc.
 - h. Zurn Plumbing Products Group; Light Commercial Operation.
 - i. Zurn Plumbing Products Group; Specification Drainage Operation.
 - 2. Pattern: Floor drain.
 - 3. Body Material: cast iron.

4. Seepage Flange: Required for upper levels.
 5. Anchor Flange: Required.
 6. Clamping Device: Required.
 7. Outlet: Bottom.
 8. Coating on Interior and Exposed Exterior Surfaces: Acid-resistant epoxy enamel.
 9. Top of Body and Strainer Finish: Polished bronze.
 10. Top Shape: round.
- B. Air-Gap Fittings:
1. Standard: ASME A112.1.2, for fitting designed to ensure fixed, positive air gap between installed inlet and outlet piping.
 2. Body: Bronze or cast iron.
 3. Inlet: Opening in top of body.
 4. Outlet: Larger than inlet.
 5. Size: Same as connected waste piping and with inlet large enough for associated indirect waste piping.
- C. Sleeve Flashing Device:
1. Description: Manufactured, cast-iron fitting, with clamping device that forms sleeve for pipe floor penetrations of floor membrane. Include galvanized-steel pipe extension in top of fitting that will extend 2 inches (51 mm) above finished floor and galvanized-steel pipe extension in bottom of fitting that will extend through floor slab.
 2. Size: As required for close fit to riser or stack piping.

2.3 FLASHING MATERIALS

- A. Lead Sheet: ASTM B 749, Type L51121, copper bearing, with the following minimum weights and thicknesses, unless otherwise indicated:
1. General Use: 4.0-lb/sq. ft. (20-kg/sq. m), 0.0625-inch (1.6-mm) thickness.
 2. Vent Pipe Flashing: 3.0-lb/sq. ft. (15-kg/sq. m), 0.0469-inch (1.2-mm) thickness.
 3. Burning: 6-lb/sq. ft. (30-kg/sq. m), 0.0938-inch (2.4-mm) thickness.
- B. Fasteners: Metal compatible with material and substrate being fastened.
- C. Metal Accessories: Sheet metal strips, clamps, anchoring devices, and similar accessory units required for installation; matching or compatible with material being installed.
- D. Solder: ASTM B 32, lead-free alloy.
- E. Bituminous Coating: SSPC-Paint 12, solvent-type, bituminous mastic.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Refer to Division 22 Section "Common Work Results for Plumbing" for piping joining materials, joint construction, and basic installation requirements.
- B. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:
1. Size same as drainage piping up to NPS 4 (DN 100). Use NPS 4 (DN 100) for larger drainage piping unless larger cleanout is indicated.
 2. Locate at each change in direction of piping greater than 45 degrees.
 3. Locate at minimum intervals of 50 feet (15 m) for piping NPS 4 (DN 100) and smaller and 100 feet (30 m) for larger piping.
 4. Locate at base of each vertical soil and waste stack.
- C. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.
- D. For cleanouts located in concealed piping, install cleanout wall access covers, with frame and cover flush with finished wall.

- E. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.
 - 1. Position floor drains for easy access and maintenance.
 - a. Set floor drains below elevation of surrounding finished floor to allow floor drainage.
 - 2. Install floor-drain flashing collar or flange so no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes where penetrated.
 - 3. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.
- F. Assemble open drain fittings and install with top of hub 2 inches above floor.
- G. Install air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system.
- H. Install sleeve flashing device with each riser and stack passing through floors with waterproof membrane.
- I. Install traps on plumbing specialty drain outlets.
- J. Install escutcheons at wall, floor, and ceiling penetrations in exposed finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding pipe fittings.

3.2 CONNECTIONS

- A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to equipment to allow service and maintenance.

3.3 FLASHING INSTALLATION

- A. Fabricate flashing from single piece unless large pans, sumps, or other drainage shapes are required. Join flashing according to the following if required:
 - 1. Copper, Aluminum or Stainless steel.
- B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors with waterproof membrane.
 - 1. Pipe Flashing: Sleeve type, matching pipe size, with minimum length of 10 inches (250 mm), and skirt or flange extending at least 8 inches (200 mm) around pipe.
 - 2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches (200 mm) around sleeve.
 - 3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches (200 mm) around specialty.
- C. Set flashing on floors in solid coating of bituminous cement.
- D. Secure flashing into sleeve and specialty clamping ring or device.

3.4 PROTECTION

- A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.
- B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 22 13 19

SECTION 22 42 00 - PLUMBING FIXTURES**PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Faucets for lavatories and sinks.
 - 2. Flushometers.
 - 3. Toilet seats.
 - 4. Fixture supports.
 - 5. Water closets.
 - 6. Urinals.
 - 7. Lavatories.
 - 8. Kitchen sinks.

1.3 DEFINITIONS

- A. ABS: Acrylonitrile-butadiene-styrene plastic.
- B. Accessible Fixture: Plumbing fixture that can be approached, entered, and used by people with disabilities.
- C. FRP: Fiberglass-reinforced plastic.
- D. PMMA: Polymethyl methacrylate (acrylic) plastic.
- E. PVC: Polyvinyl chloride plastic.
- F. Solid Surface: Nonporous, homogeneous, cast-polymer-plastic material with heat-, impact-, scratch-, and stain-resistance qualities.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: Diagram power, signal, and control wiring.
- C. Operation and maintenance data.

1.5 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Regulatory Requirements: Comply with requirements in ICC A117.1, "Accessible and Usable Buildings and Facilities"; Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act"; for plumbing fixtures for people with disabilities.
- C. Regulatory Requirements: Comply with requirements in Public Law 102-486, "Energy Policy Act," about water flow and consumption rates for plumbing fixtures.
- D. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.
- E. Select combinations of fixtures and trim, faucets, fittings, and other components that are compatible.
- F. Comply with the following applicable standards and other requirements specified for plumbing fixtures:

1. Enameled, Cast-Iron Fixtures: ASME A112.19.1M.
2. Solid-Surface-Material Lavatories and Sinks: ANSI/ICPA SS-1.
3. Vitreous-China Fixtures: ASME A112.19.2M.
4. Water-Closet, Flush Valve,: ASME A112.19.5.
- G. Comply with the following applicable standards and other requirements specified for lavatory and sink faucets:
 1. Faucets: ASME A112.18.1.
 2. Integral, Atmospheric Vacuum Breakers: ASSE 1001.
 3. NSF Potable-Water Materials: NSF 61.
 4. Pipe Threads: ASME B1.20.1.
 5. Supply Fittings: ASME A112.18.1.
 6. Brass Waste Fittings: ASME A112.18.2.
- H. Comply with the following applicable standards and other requirements specified for miscellaneous fittings:
 1. Atmospheric Vacuum Breakers: ASSE 1001.
 2. Brass and Copper Supplies: ASME A112.18.1.
 3. Manual-Operation Flushometers: ASSE 1037.
 4. Plastic Tubular Fittings: ASTM F 409.
 5. Brass Waste Fittings: ASME A112.18.2.
- I. Comply with the following applicable standards and other requirements specified for miscellaneous components:
 1. Flexible Water Connectors: ASME A112.18.6.
 2. Grab Bars: ASTM F 446.
 3. Hose-Coupling Threads: ASME B1.20.7.
 4. Pipe Threads: ASME B1.20.1.
 5. Plastic Toilet Seats: ANSI Z124.5.

PART 2 - PRODUCTS

- 2.1 REFERENCE PLUMBING SHEETS FOR FIXTURE INFORMATION.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Assemble plumbing fixtures, trim, fittings, and other components according to manufacturers' written instructions.
- B. Install off-floor supports, affixed to building substrate, for wall-mounting fixtures.
 1. Use carrier supports with waste fitting and seal for back-outlet fixtures.
 2. Use carrier supports without waste fitting for fixtures with tubular waste piping.
 3. Use chair-type carrier supports with rectangular steel uprights for accessible fixtures.
- C. Install back-outlet, wall-mounting fixtures onto waste fitting seals and attach to supports.
- D. Install floor-mounting fixtures on closet flanges or other attachments to piping or building substrate.
- E. Install wall-mounting fixtures with tubular waste piping attached to supports.
- F. Install fixtures level and plumb according to roughing-in drawings.
- G. Install water-supply piping with stop on each supply to each fixture to be connected to water distribution piping. Attach supplies to supports or substrate within pipe spaces behind fixtures. Install stops in locations where they can be easily reached for operation.

- H. Install trap and tubular waste piping on drain outlet of each fixture to be directly connected to sanitary drainage system.
- I. Install tubular waste piping on drain outlet of each fixture to be indirectly connected to drainage system.
- J. Install flushometer valves for accessible water closets and urinals with handle mounted on wide side of compartment. Install other actuators in locations that are easy for people with disabilities to reach.
- K. Install toilet seats on water closets.
- L. Install faucet-spout fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.
- M. Install water-supply flow-control fittings with specified flow rates in fixture supplies at stop valves.
- N. Install faucet flow-control fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.
- O. Install escutcheons at piping wall and ceiling penetrations in exposed, finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding fittings. Escutcheons are specified in Division 22 Section "Common Work Results for Plumbing."
- P. Seal joints between fixtures and walls, floors, and countertops using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Sealants are specified in Division 07 Section "Joint Sealants."

3.2 CONNECTIONS

- A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.
- C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- E. Division 22000 shall provide rough-ins and that make final connection to any equipment provided by others such as ice maker, and dish washer.

3.3 FIELD QUALITY CONTROL

- A. Verify that installed plumbing fixtures are categories and types specified for locations where installed.
- B. Check that plumbing fixtures are complete with trim, faucets, fittings, and other specified components.
- C. Inspect installed plumbing fixtures for damage. Replace damaged fixtures and components.
- D. Test installed fixtures after water systems are pressurized for proper operation. Replace malfunctioning fixtures and components, then retest. Repeat procedure until units operate properly.
- E. Install fresh batteries in sensor-operated mechanisms.

3.4 PROTECTION

- A. Provide protective covering for installed fixtures and fittings.
- B. Do not allow use of plumbing fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION 22 40 00

SECTION 22 45 00 - EMERGENCY PLUMBING FIXTURES**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. Combination units.
 - 2. Water-tempering equipment.

1.3 DEFINITIONS

- A. Accessible Fixture: Emergency plumbing fixture that can be approached, entered, and used by people with disabilities.
- B. Plumbed Emergency Plumbing Fixture: Fixture with fixed, potable-water supply.
- C. Self-Contained Emergency Plumbing Fixture: Fixture with flushing-fluid-solution supply.
- D. Tepid: Moderately warm.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include flow rates and capacities, furnished specialties, and accessories.
- B. Shop Drawings:
 - 1. Include plans, elevations, sections, and **mounting** 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.

1.5 INFORMATIONAL SUBMITTALS

- A. Product Certificates: Submit certificates of performance testing specified in "Source Quality Control" Article.
- B. Field quality-control test reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For emergency plumbing fixtures to include in operation and maintenance manuals.

PART 2 - PRODUCTS**2.1 PERFORMANCE REQUIREMENTS**

- A. ISEA Standard: Comply with ISEA Z358.1.
- B. NSF Standard: Comply with NSF 61 and NSF 372, for fixture materials that will be in contact with potable water.
- C. Regulatory Requirements: Comply with requirements in ICC A117.1.; Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act"; for plumbing fixtures for people with disabilities.

2.2 COMBINATION UNITS

- A. Accessible, Plumbed Emergency Shower with Eyewash Combination Units,
 - 1. Piping:
 - a. Material: stainless steel.
 - b. Unit Supply: NPS 1-1/4 minimum.
 - c. Unit Drain: Outlet at back or side near bottom.
 - 2. Shower:
 - a. Capacity: Not less than 20 gpm for at least 15 minutes.
 - b. Supply Piping: NPS 1 with flow regulator and stay-open control valve.
 - c. Control-Valve Actuator: Pull rod.
 - d. Shower Head: 8-inch- minimum diameter, plastic.
 - e. Mounting: Pedestal.
 - 3. Eyewash Unit:
 - a. Capacity: Not less than 0.4 gpm for at least 15 minutes.
 - b. Supply Piping: NPS 1/2 with flow regulator and stay-open control valve.
 - c. Control-Valve Actuator: Paddle.
 - d. Spray-Head Assembly: Two receptor-mounted spray heads.
 - e. Receptor: **Chrome-plated brass or stainless-steel** bowl.
 - f. Mounting: Attached shower pedestal.

2.3 WATER-TEMPERING EQUIPMENT

- A. Hot- and Cold-Water, Water-Tempering Equipment, **<Insert drawing designation>**:
 - 1. Description: Factory-fabricated equipment with thermostatic mixing valve.
 - a. Thermostatic Mixing Valve: Designed to provide **85 deg F** tepid, potable water at emergency plumbing fixtures, to maintain temperature at plus or minus **5 deg F** throughout required 15-minute test period, and in case of unit failure to continue cold-water flow, with union connections, controls, metal piping, and corrosion-resistant enclosure.
 - b. Supply Connections: For hot and cold water.

PART 3 - EXECUTION**3.1 EXAMINATION**

- A. Examine roughing-in for water piping systems to verify actual locations of piping connections before plumbed emergency plumbing fixture installation.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF EMERGENCY PLUMBING FIXTURE INSTALLATION

- A. Assemble emergency plumbing fixture piping, fittings, control valves, and other components.
- B. Install fixtures level and plumb.
- C. Fasten fixtures to substrate.
- D. Install shutoff valves in water-supply piping to fixtures, to facilitate maintenance of the equipment. Use ball or gate valve if specific type valve is not indicated. Install valves chained or locked in open position if permitted. Install valves in locations where they can easily be reached for operation. Comply with requirements for valves specified in Section 220523.12 "Ball Valves for Plumbing Piping" and Section 220523.15 "Gate Valves for Plumbing Piping."
 - 1. Exception: Omit shutoff valve on supply to group of plumbing fixtures that includes emergency equipment.
 - 2. Exception: Omit shutoff valve on supply to emergency equipment if prohibited by authorities having jurisdiction.
- E. Install shutoff valve and strainer in steam piping and shutoff valve in condensate return piping. Comply with requirements for steam and condensate piping specified in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties."
- F. Install dielectric fitting in supply piping to emergency equipment if piping and equipment connections are made of different metals. Comply with requirements for dielectric fittings specified in Section 221116 "Domestic Water Piping."
- G. Install thermometers in supply and outlet piping connections to water-tempering equipment. Comply with requirements for thermometers specified in Section 220519 "Meters and Gages for Plumbing Piping."
- H. Install trap and waste piping on drain outlet of emergency equipment receptors that are indicated to be directly connected to drainage system. Comply with requirements for waste piping specified in Section 221316 "Sanitary Waste and Vent Piping."
- I. Install indirect waste piping on drain outlet of emergency equipment receptors that are indicated to be indirectly connected to drainage system. Comply with requirements for waste piping specified in Section 221316 "Sanitary Waste and Vent Piping."
- J. Install escutcheons on piping wall and ceiling penetrations in exposed, finished locations. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."
- K. Fill self-contained fixtures with flushing fluid.

3.3 CONNECTIONS

- A. Connect cold-water-supply piping to plumbed emergency plumbing fixtures not having water-tempering equipment. Comply with requirements for cold-water piping specified in Section 221116 "Domestic Water Piping."
- B. Connect hot- and cold-water-supply piping to hot- and cold-water, water-tempering equipment. Connect output from water-tempering equipment to emergency plumbing fixtures. Comply with requirements for hot- and cold-water piping specified in Section 221116 "Domestic Water Piping."
- C. Connect steam and cold-water-supply and condensate return piping to steam and cold water-tempering equipment. Connect output from water-tempering equipment to emergency plumbing fixtures. Comply with requirements for cold-water piping specified in Section 221116 "Domestic Water Piping" and comply with requirements for steam and condensate piping specified in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties."
- D. Connect cold water and electrical power to electric heating water-tempering equipment. Comply with requirements for cold-water piping specified in Section 221116 "Domestic Water Piping."
- E. Directly connect emergency plumbing fixture receptors with trapped drain outlet to sanitary waste and vent piping. Comply with requirements for waste piping specified in Section 221316 "Sanitary Waste and Vent Piping."

- F. Indirectly connect emergency plumbing fixture receptors without trapped drain outlet to sanitary waste or storm drainage piping.
- G. Where installing piping adjacent to emergency plumbing fixtures, allow space for service and maintenance of fixtures.

3.4 IDENTIFICATION

- A. Install equipment nameplates or equipment markers on emergency plumbing fixtures and equipment and equipment signs on water-tempering equipment. Comply with requirements for identification materials specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.5 FIELD QUALITY CONTROL

- A. Mechanical-Component Testing: After plumbing connections have been made, test for compliance with requirements. Verify ability to achieve indicated capacities.
- B. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection.
 - 2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Emergency plumbing fixtures and water-tempering equipment will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

3.6 ADJUSTING

- A. Adjust or replace fixture flow regulators for proper flow.
- B. Adjust equipment temperature settings.

END OF SECTION 22 45 00

SECTION 22 47 00 - DRINKING FOUNTAINS AND WATER COOLERS**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 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of electric drinking fountains or workmanship within specified warranty period.
 - 1. Warranty Period: **Five years** from date of Final Acceptance.

1.3 SUMMARY

- A. This Section includes the following:
 - 1. Style W, wall-mounting drinking fountains.
 - 2. Fixture supports.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: Diagram power, signal, and control wiring.
- C. Operation and maintenance data.

1.5 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Regulatory Requirements: Comply with requirements in ICC A117.1, "Accessible and Usable Buildings and Facilities"; Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act"; for fixtures for people with disabilities.
- C. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.
- D. ARI Standard: Comply with ARI's "Directory of Certified Drinking Water Coolers" for style classifications.
- E. ARI Standard: Comply with ARI 1010, "Self-Contained, Mechanically Refrigerated Drinking-Water Coolers," for water coolers and with ARI's "Directory of Certified Drinking Water Coolers" for type and style classifications.
- F. ASHRAE Standard: Comply with ASHRAE 34, "Designation and Safety Classification of Refrigerants" for water coolers. Provide HFC 134a (tetrafluoroethane) refrigerant unless otherwise indicated.

PART 2 - PRODUCTS**2.1 WATER COOLERS:**

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

1. Elkay Manufacturing Co.
 2. Halsey Taylor.
 3. Haws Corporation.
 4. Oasis Corporation.
 5. Sunroc Corp.
- B. Description: Accessible, ARI 1010, Type PB, pressure with bubbler, Style W, wall-mounting water cooler for adult mounting height.
1. Cabinet: Bilevel with two attached cabinets and with bilevel skirt kit, all stainless steel top
 2. Bubbler: One, with adjustable stream regulator, located on each cabinet deck.
 3. Control: Push bar.
 4. Supply: NPS 3/8 (DN 10) with ball, gate, or globe valve.
 5. Drain(s): Grid with NPS 1-1/4 minimum horizontal waste and trap complying with ASME A112.18.1.
 6. Cooling System: Electric, with hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, refrigerant, corrosion-resistant-metal storage tank, and adjustable thermostat.
 - a. Capacity: 5 gph of 50 deg F cooled water from 80 deg F inlet water and 90 deg F ambient air temperature.
 - b. Electrical Characteristics: 1/4 hp; 120-V ac; single phase; 60 Hz.
 7. Support: Type II, water cooler carrier. Refer to "Fixture Supports" Article.

2.2 FIXTURE SUPPORTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Josam Co.
 2. MIFAB Manufacturing, Inc.
 3. Smith, Jay R. Mfg. Co.
 4. Tyler Pipe; Wade Div.
 5. Watts Drainage Products Inc.; a div. of Watts Industries, Inc.
 6. Zurn Plumbing Products Group; Specification Drainage Operation.
- B. Description: ASME A112.6.1M, water cooler carriers. Include vertical, steel uprights with feet and tie rods and bearing plates with mounting studs matching fixture to be supported.
1. Type I: Hanger-type carrier with two vertical uprights.
 2. Supports for Accessible Fixtures: Include rectangular, vertical, steel uprights instead of steel pipe uprights.

PART 3 - EXECUTION

3.1 APPLICATIONS

- A. Use carrier off-floor supports for wall-mounting fixtures, unless otherwise indicated.
- B. Set freestanding and pedestal drinking fountains on floor.
- C. Use chrome-plated brass or copper tube, fittings, and valves in locations exposed to view.

3.2 INSTALLATION

- A. Install off-floor supports affixed to building substrate and attach wall-mounting fixtures, unless otherwise indicated.
- B. Install fixtures level and plumb. For fixtures indicated for children, install at height required by authorities having jurisdiction.

- C. Install water-supply piping with shutoff valve on supply to each fixture to be connected to water distribution piping. Use ball, gate, or globe valve. Install valves in locations where they can be easily reached for operation. Valves are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."
- D. Install trap and waste piping on drain outlet of each fixture to be connected to sanitary drainage system.
- E. Install pipe escutcheons at wall penetrations in exposed, finished locations. Use deep-pattern escutcheons where required to conceal protruding pipe fittings. Escutcheons are specified in Division 22 Section "Common Work Results for Plumbing."
- F. Seal joints between fixtures and walls and floors using sanitary-type, one-part, mildew-resistant, silicone sealant. Match sealant color to fixture color. Sealants are specified in Division 07 Section "Joint Sealants."

3.3 CONNECTIONS

- A. Connect fixtures with water supplies, traps, and risers, and with soil, waste, and vent piping. Use size fittings required to match fixtures.
- B. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- C. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

- A. Water Cooler Testing: After electrical circuitry has been energized, test for compliance with requirements. Test and adjust controls and safeties.
 - 1. Remove and replace malfunctioning units and retest as specified above.
 - 2. Report test results in writing.

3.5 ADJUSTING

- A. Adjust fixture flow regulators for proper flow and stream height.
- B. Adjust water cooler temperature settings.

END OF SECTION 22 47 00

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SECTION 23 00 10 – COORDINATION DRAWINGS**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 COORDINATION DRAWINGS

- A. Coordination drawings shall be prepared, and submitted for review by the Designer, indicating structural and other miscellaneous steel, and HVAC, Plumbing, Fire Protection, Electrical, and General work which must be carefully coordinated by all trades to minimize space conflicts. These drawings shall be submitted for review prior to any trade starting work which is in close proximity to work of any other trade(s).
- B. The Contractor shall be responsible for the preparation and submission of the coordination drawings. Specific efforts required include:
 - 1. Initiation of the drawings including furnishing of reproducible sheet which show Floor Plans with structural steel and HVAC elements.
 - 2. Coordination/communication with other trades during the preparation of the coordination drawings.
 - 3. Minimizing future conflicts between trades.
- C. Each subcontractor shall be responsible for showing the elements of their work on the coordination drawings. The HVAC Contractor is only responsible for showing elements relative to his work and the conflicts. These coordination drawings shall represent a collective effort by all contractors to avoid space conflicts and expedite the work of all trades. Work may not proceed until the coordination drawings have been reviewed for general conformance by the Designer.
- D. Prepare coordination drawings to a scale of $\frac{1}{4}" = 1'-0"$ or larger; detailing major elements, components, and systems of HVAC, plumbing, fire protection, and electrical equipment and materials in relationship with other systems, installations, and building structural steel and components. Dimension elements and components of the systems from column lines and indicate elevations of elements and components relative to the finished floor. Indicate location 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. At minimum, the coordination drawings shall include (but not necessarily be limited to) the following:
 - 1. Indicate all structural and miscellaneous steel.
 - 2. Indicated the proposed location of all ductwork and air distribution equipment including terminal units and diffusers.
 - 3. Indicate the proposed location of piping services including:
 - a. Chilled water piping.
 - b. Heating hot water piping.
 - c. Domestic hot and cold water piping.
 - d. Waste and vent piping.
 - e. Roof drain/rain leader piping.
 - f. Sprinkler piping and sprinkler heads.
 - g. Cable trays.
 - h. Wireways.
 - 4. Indicate the proposed location of electrical conduits and all light fixtures.
 - 5. Indicate clearances for installing and maintaining insulation.
 - 6. Indicate clearances for servicing and maintaining equipment, including tube removal, filter removal, and space for equipment disassembly required for periodic maintenance.

7. Indicate major equipment, equipment support details, and connections.
 8. Indicate sizes and locations of required concrete housekeeping pads and bases.
 9. Indicate all fire-rated walls and partitions.
 10. Indicate scheduling, sequencing, movement, and positioning of large equipment into the building during construction.
 11. Prepare separate floor plans, sections, and details as required to indicate all piping and conduits routed through structural steel openings.
 12. Prepare separate reflected ceiling plans to coordinate and integrate installations of air outlets and inlets, light fixtures, communication systems components, sprinkler heads, and other ceiling-mounted items.
 13. It is not required (unless otherwise noted above) to indicate piping and conduit 1-1/4 inches in diameter and smaller on the coordination drawings. However, the respective trade installing such elements assumes responsibility for coordinating and installing said elements in a manner that does not conflict with other elements shown on the coordination drawings.
- E. Upon completion of the coordination drawings, a representative of each trade contractor shall be required to sign each sheet of the coordination drawings. Signature shall attest to a diligent review of the coordination drawings and agreement to alleviate/resolve any future space conflicts at no cost to the Owner.
- F. Failure by the contractor who is in violation of the coordination drawings to move his work, or reimburse the affected contractor or the Owner, will result in the monetary amount required to resolve the conflict to be deducted from his contract.
- G. Coordination drawings must be complete and submitted to the Designer for review within one month following the Date of Commencement. The Designer's review shall not denote responsibility of the content of the coordination drawings on his part, but to check for general conformity and requirements of the Contract Documents.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 23 00 10

SECTION 23 05 00 - COMMON WORK RESULTS FOR HVAC**PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Sleeves.
 - 2. Escutcheons.
 - 3. Equipment installation requirements common to equipment sections.
 - 4. Concrete bases.
 - 5. Supports and anchorages.

1.3 DEFINITIONS

- A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspace, and tunnels.
- B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
- C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
- D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and chases.
- E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

1.4 SUBMITTALS

- A. Welding certificates.

1.5 QUALITY ASSURANCE

- A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."
- B. Non-Destructive Inspection and Testing: A/E shall visually inspect pipe welds. Based on visual inspections, upon order of the A/E, non-destructive testing of selected pipe welds shall be performed by a qualified testing agency, at the expense of the Owner, using one of the following methods selected by the A/E. The welds inspected shall be selected randomly, but the selection shall include an examination of welds made by each welding operator or welder.
 - 1. Radiographic testing in accordance with ASTM E 94:
 - a. Make identification of defects by comparing radiographs to reference radiographs in ASTM E 390.
 - b. Film shall positively and properly identify as to member being inspected, location of weld, and location of film on weld.
 - c. Stamp identification on steel so film may be easily identified and matched to identification mark
 - 2. Ultrasonic testing in accordance with ASTM E 164:

- a. Size of defects will be determined by relating amplitude of oscilloscope traces to hole in ASTM reference weldment.
 - b. Diameter of reference holes shall be 3/32-inch.
 - c. Weld defects which are cause for rejection include cracks, lack of fusion, incomplete penetration, porosity, or slag inclusions which produce reflections equal to or greater than 80 percent of reference hole reflection and have linear dimensions as indicated by transducer movement exceeding 1/4-inch for material thickness up to and including 3/4-inch.
- C. Correction of Defective Welds: If random testing reveals that any welds fail to meet minimum quality requirements, an additional 10 percent of the welds in that same group shall be inspected at the Contractor's expense. If all of the additional welds inspected meet the quality requirements, the entire group of welds represented shall be accepted and the defective welds shall be repaired. If any of the additional welds inspected also fail to meet the quality requirements, that entire group of welds shall be rejected. At the Contractor's option, the rejected welds shall be removed and the joints rewelded or the rejected welds shall be 100 percent tested as hereinbefore specified and all defective weld areas removed and rewelded.
- D. Electrical Characteristics for HVAC Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements. No additional cost will be allowed for such changes and substitutions.

PART 2 - PRODUCTS

2.1 PIPE, TUBE, AND FITTINGS

- A. Use type L copper piping for all condensate drain piping

2.2 JOINING MATERIALS

- A. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
- B. Brazing Filler Metals: AWS A5.8, BCuP Series or BAg1, unless otherwise indicated.

2.3 SLEEVES

- A. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.

2.4 ESCUTCHEONS

- A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.
- B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.
- C. One-Piece, Cast-Brass Type: With set screw.
 - 1. Finish: Polished chrome-plated
- D. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.
 - 1. Finish: Polished chrome-plated

2.5 GROUT

- A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
 - 1. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
 - 2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
 - 3. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

- A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.
- B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.
- C. Install HVAC equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.
- D. Install equipment to allow right of way for piping installed at required slope.

3.2 CONCRETE BASES

- A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.

3.3 ERECTION OF METAL SUPPORTS AND ANCHORAGES

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

3.4 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

- A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor HVAC materials and equipment.
- B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.
- C. Attach to substrates as required to support applied loads.

3.5 GROUTING

- A. Mix and install grout for HVAC equipment base bearing surfaces, pump and other equipment base plates, and anchors.
- B. Clean surfaces that will come into contact with grout.
- C. Provide forms as required for placement of grout.
- D. Avoid air entrapment during placement of grout.
- E. Place grout, completely filling equipment bases.
- F. Place grout on concrete bases and provide smooth bearing surface for equipment.
- G. Place grout around anchors.
- H. Cure placed grout.

END OF SECTION 23 05 00

SECTION 23 05 13 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT**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 general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on ac power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.3 COORDINATION

- A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
 - 1. Motor controllers.
 - 2. Torque, speed, and horsepower requirements of the load.
 - 3. Ratings and characteristics of supply circuit and required control sequence.
 - 4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS**2.1 GENERAL MOTOR REQUIREMENTS**

- A. Comply with requirements in this Section except when stricter requirements are specified in HVAC equipment schedules or Sections.
- B. Comply with NEMA MG 1 unless otherwise indicated.
- C. Provide with shaft grounding rings

2.2 MOTOR CHARACTERISTICS

- A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet (1000 m) above sea level.
- B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 POLYPHASE MOTORS

- A. Description: NEMA MG 1, Design B, medium induction motor.
- B. Efficiency: Premium Efficiency, as defined in NEMA MG 1.
- C. Service Factor: 1.15.
- D. Multispeed Motors: Variable torque.
 - 1. For motors with 2:1 speed ratio, consequent pole, single winding.
 - 2. For motors with other than 2:1 speed ratio, separate winding for each speed.
- E. Rotor: Random-wound, squirrel cage.
- F. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

- G. Temperature Rise: Match insulation rating.
- H. Insulation: Class F Code Letter Designation:
 - 1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
 - 2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.
- I. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

- A. Motors Used with Reduced-Voltage and Multi-speed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.
- B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
 - 1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
 - 2. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
 - 3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
 - 4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
 - 5. Provide with shaft grounding rings.

2.5 SINGLE-PHASE MOTORS

- A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:
 - 1. Permanent-split capacitor.
 - 2. Capacitor start, inductor run.
 - 3. Capacitor start, capacitor run.
- B. Multispeed Motors: Electronically Commutated (ECM).
- C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
- D. Motors 1/20 HP and Smaller: Shaded-pole type.
- E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 23 05 13

SECTION 23 05 29 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Steel pipe hangers and supports.
 - 2. Trapeze pipe hangers.
 - 3. Metal framing systems.
 - 4. Fastener systems.
 - 5. Equipment supports.

1.3 DEFINITIONS

- A. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

1.4 PERFORMANCE REQUIREMENTS

- A. Design supports for multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.
- B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
- C. Retain a registered engineer to design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.

1.5 SUBMITTALS

- A. Product Data: For the following:
 - 1. Steel pipe hangers and supports.
 - 2. Powder-actuated fastener systems.
 - 3. Shop Drawings: Signed and sealed by a qualified professional engineer showing seismic-restraint hangers and supports for piping and equipment
- B. Welding certificates.

1.6 QUALITY ASSURANCE

- A. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 EQUIPMENT SUPPORTS

- A. Description: Welded, shop- or field-fabricated equipment support made from structural-steel shapes.

2.3 MISCELLANEOUS MATERIALS

- A. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
- B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
 - 1. Properties: Nonstaining, noncorrosive, and nongaseous.
 - 2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

- A. Specific hanger and support requirements are specified in Sections specifying piping systems and equipment.

3.2 EQUIPMENT SUPPORTS

- A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.
- B. Grouting: Place grout under supports for equipment and make smooth bearing surface.
- C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.3 METAL FABRICATIONS

- A. Field Welding: Comply with AWS D1.1 procedures for shielded metal arc welding, appearance and quality of welds, and methods used in correcting welding work, and with the following:
 - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - 2. Obtain fusion without undercut or overlap.
 - 3. Remove welding flux immediately.
 - 4. Finish welds at exposed connections so no roughness shows after finishing and contours of welded surfaces match adjacent contours.

3.4 ADJUSTING

- A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

3.5 PAINTING

- A. Touch Up: 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 (0.05 mm).
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 23 05 29

SECTION 23 05 48 - VIBRATION AND SEISMIC CONTROLS FOR HVAC**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes:
 - 1. Elastomeric isolation pads.
 - 2. Restrained elastomeric isolation mounts.
 - 3. Restrained-spring isolators.
 - 4. Pipe-riser resilient supports.
 - 5. Resilient pipe guides.
 - 6. Elastomeric hangers.
 - 7. Spring hangers.
 - 8. Snubbers.
 - 9. Restraint channel bracings.
 - 10. Restraint cables.
 - 11. Seismic-restraint accessories.
 - 12. Mechanical anchor bolts.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Delegated-Design Submittal: For each vibration isolation and seismic-restraint device.
 - 1. Include design calculations and details for selecting vibration isolators and seismic restraints complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.3 INFORMATIONAL SUBMITTALS

- A. Welding certificates.
- B. Field quality-control reports.

1.4 QUALITY ASSURANCE

- A. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.
- B. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- C. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are unavailable, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

PART 2 - PRODUCTS**2.1 PERFORMANCE REQUIREMENTS**

- 1. Reference Drawing S001 for seismic information.

2.2 ELASTOMERIC ISOLATION PADS

- A. Elastomeric Isolation Pads:
 - 1. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
 - 2. Size: Factory or field cut to match requirements of supported equipment.
 - 3. Pad Material: Oil and water resistant with elastomeric properties.
 - 4. Surface Pattern: Waffle pattern.
 - 5. Infused nonwoven cotton or synthetic fibers.
 - 6. Load-bearing metal plates adhered to pads.

2.3 RESTRAINED ELASTOMERIC ISOLATION MOUNTS

- A. Restrained Elastomeric Isolation Mounts:
 - 1. Description: All-directional isolator with seismic restraints containing two separate and opposing elastomeric elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
 - a. Housing: Cast-ductile iron or welded steel.
 - b. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.4 RESTRAINED-SPRING ISOLATORS

- A. Freestanding, Laterally Stable, Open-Spring Isolators with Vertical-Limit Stop Restraint:
 - 1. Housing: Steel housing with vertical-limit stops to prevent spring extension due to weight being removed.
 - a. Base with holes for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig (3447 kPa).
 - b. Top plate with threaded mounting holes.
 - c. Internal leveling bolt that acts as blocking during installation.
 - 2. Restraint: Limit stop as required for equipment and authorities having jurisdiction.
 - 3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 - 4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 - 5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 - 6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.5 PIPE-RISER RESILIENT SUPPORT

- A. Description: All-directional, acoustical pipe anchor consisting of two steel tubes separated by a minimum 1/2-inch- (13-mm-) thick neoprene.
 - 1. Vertical-Limit Stops: Steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions.
 - 2. Maximum Load Per Support: 500 psig (3.45 MPa) on isolation material providing equal isolation in all directions.

2.6 RESILIENT PIPE GUIDES

- A. Description: Telescopic arrangement of two steel tubes or post and sleeve arrangement separated by a minimum 1/2-inch- (13-mm-) thick neoprene.
 - 1. Factory-Set Height Guide with Shear Pin: Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.7 ELASTOMERIC HANGERS

- A. Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods:
 - 1. Frame: Steel, fabricated with a connection for an upper threaded hanger rod and an opening on the underside to allow for a maximum of 30 degrees of angular lower hanger-rod misalignment without binding or reducing isolation efficiency.
 - 2. Dampening Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel to steel contact.

2.8 SPRING HANGERS

- A. Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression:
 - 1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
 - 2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 - 3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 - 4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 - 5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 - 6. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
 - 7. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
 - 8. Self-centering hanger-rod cap to ensure concentricity between hanger rod and support spring coil.

2.9 SNUBBERS

- A. Description: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.
 - 1. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and stud-wedge or female-wedge type.
 - 2. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
 - 3. Maximum 1/4-inch (6-mm) air gap, and minimum 1/4-inch- (6-mm-) thick resilient cushion.

2.10 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 and other matching components and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.11 RESTRAINT CABLES

- A. Restraint Cables: ASTM A603 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.

2.12 SEISMIC-RESTRAINT ACCESSORIES

- A. Hanger-Rod Stiffener: Reinforcing steel angle clamped to hanger rod.

- B. 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.
- C. 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.
- D. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.
- E. 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 E488.

PART 3 - EXECUTION

3.1 APPLICATIONS

- A. Multiple Pipe Supports: Secure pipes 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 due to seismic forces.
- C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength is adequate to carry present and future static and seismic loads within specified loading limits.

3.2 VIBRATION CONTROL AND 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. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.
- C. Comply with requirements in Section 077200 "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.
- D. Equipment Restraints:
 - 1. Install seismic snubbers on HVAC equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
 - 2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch (3.2 mm).
 - 3. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.
- E. Piping Restraints:
 - 1. Comply with requirements in MSS SP-127.
 - 2. Space lateral supports a maximum of [40 feet (12 m) o.c., and longitudinal supports a maximum of [80 feet (24 m) o.c.
 - 3. Brace a change of direction longer than 12 feet (3.7 m).
- F. Install cables so they do not bend across edges of adjacent equipment or building structure.
- G. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.
- H. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.
- I. 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.
- J. 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.
- K. Drilled-in Anchors:

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

3.3 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

- A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Section 232113 "Hydronic Piping" for piping flexible connections.

3.4 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Perform tests and inspections.
- C. Tests and Inspections:
 1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
 2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless post connection testing has been approved), and with at least seven days' advance notice.
 3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
 4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
 5. Test to 90 percent of rated proof load of device.
 6. Measure isolator restraint clearance.
 7. Measure isolator deflection.
 8. Verify snubber minimum clearances.
- D. Remove and replace malfunctioning units and retest as specified above.
- E. Prepare test and inspection reports.

3.5 ADJUSTING

- A. Adjust isolators after piping system is at operating weight.
- B. Adjust limit stops on restrained-spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

END OF SECTION 23 05 48

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SECTION 23 05 53 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following mechanical identification materials and their installation:
 - 1. Equipment nameplates.
 - 2. Equipment markers.
 - 3. Equipment signs.
 - 4. Access panel and door markers.
 - 5. Pipe markers.
 - 6. Stencils.
 - 7. Valve tags.
 - 8. Valve schedules.
 - 9. Warning tags.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Samples: For color, letter style, and graphic representation required for each identification material and device.
- C. Valve numbering scheme.
- D. Valve Schedules: For each piping system. Furnish extra copies (in addition to mounted copies) to include in maintenance manuals.

1.4 QUALITY ASSURANCE

- A. ASME Compliance: Comply with ASME A13.1, "Scheme for the Identification of Piping Systems," for letter size, length of color field, colors, and viewing angles of identification devices for piping.

1.5 COORDINATION

- A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- B. Coordinate installation of identifying devices with location of access panels and doors.
- C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 EQUIPMENT IDENTIFICATION DEVICES

- A. Equipment Nameplates: Metal, with data engraved or stamped, for permanent attachment on equipment.
 - 1. Data:
 - a. Manufacturer, product name, model number, and serial number.
 - b. Capacity, operating and power characteristics, and essential data.

- c. Labels of tested compliances.
 - 2. Location: Accessible and visible.
 - 3. Fasteners: As required to mount on equipment.
 - B. Equipment Markers: Engraved phenolic plates white background and black lettering securely fastened to the equipment with sheet metal screws.
 - 1. Terminology: Match schedules as closely as possible.
 - 2. Data:
 - a. Name and plan number.
 - b. Equipment service.
 - c. Design capacity.
 - d. Other design parameters such as pressure drop, entering and leaving conditions, and speed.
 - 3. Size: 2-1/2 by 4 inches (64 by 100 mm) for control devices, dampers, and valves; 4-1/2 by 6 inches (115 by 150 mm) for equipment.
 - C. Equipment Signs: ASTM D 709, Type I, cellulose, paper-base, Engraved phenolic plates white background and black lettering. Provide holes for mechanical fastening.
 - 1. Data: Instructions for operation of equipment and for safety procedures.
 - 2. Engraving: Manufacturer's standard letter style, of sizes and with terms to match equipment identification.
 - 3. Thickness: 1/16 inch (1.6 mm) for units up to 20 sq. in. (130 sq. cm) or 8 inches (200 mm) in length, and 1/8 inch (3.2 mm) for larger units.
 - 4. Fasteners: Self-tapping, stainless-steel sheet-metal screws..
 - D. Access Panel and Door Markers: 1/16-inch- (1.6-mm-) thick, engraved laminated plastic, with abbreviated terms and numbers corresponding to identification. Provide 1/8-inch (3.2-mm) center hole for attachment.
 - 1. Fasteners: Self-tapping, stainless-steel screws or contact-type, permanent adhesive.

2.2 PIPING IDENTIFICATION DEVICES

- A. Completely paint piping systems in mechanical rooms with the applicable colors listed below with appropriate self-sticking or strap-on identifications and arrows indicating direction of flow.
- B. On straight runs of piping, space marking no further than 30 feet apart; and with pre-tentioned Plastic Pipe Markers near each valve, pressure reducing valve, heat exchanger, etc.
- C. Where pipe passes through walls or floors, mark near the penetration on both sides. Provide markings at each directional change of all piping systems.
- D. Mechanical room and outdoor pipe color and the colors of bands are as follows:

Service	Marker Wording	Lettering Color	Background Color	Pipe/Covering Color
Domestic cold water	DOMESTIC COLD WATER	White	Green	Blue
Domestic hot water	DOMESTIC HOT WATER	Black	Yellow	Lt. Red
Domestic hot water recirculating	DOMESTIC HOT WATER RETURN	Black	Yellow	Orange
Domestic make-up water	MAKE-UP WATER	White	Green	Blue
Make-up water non-potable	NON-POTABLE MAKE-UP WATER	Black	Yellow	Purple
Sanitary drain	SANITARY DRAIN	White	Green	*
Storm drain, incl. roof drains	STORM DRAIN	White	Green	*
Plumbing vent	VENT	White	Green	*
Condensate drain	DRAIN	White	Green	*

* Pipe not painted unless exposed

Color	Sherwin Williams Industrial & Marine Coatings Paint Number	Sherwin Williams All Surface Enamel Paint Number
Yellow	Safety Yellow SW 4084	Safety Yellow 502
Orange	Safety Orange SW 4083	N/A
Green	Cedar Green SW 4072	Hunter Green 510
Light Green	Safety Green SW 4085	Safety Green 506
Blue	N/A	Navy Blue 509
Light Blue	Safety Blue SW 4086	Safety Blue 505
Red	N/A	Apple Red 511
Light Red	Safety Red SW 4081	Safety Red 507
White	Ultra White SW 4087	Extreme White 500
Black	Black SW 4090	Black 501
Purple	Plum SW 4080	N/A

- E. Additional Labeling requirements
 - 1. Colors: Comply with ASME A13.1, unless otherwise indicated.
 - 2. Lettering: Use piping system terms indicated and abbreviate only as necessary for each application length
 - 3. Pipes with OD, Including Insulation, Less Than 6 Inches (150 mm): Full-band pipe markers extending 360 degrees around pipe at each location.
 - 4. Pipes with OD, Including Insulation, 6 Inches (150 mm) and Larger: Either full-band or strip-type pipe markers at least three times letter height and of length required for label.
 - 5. Arrows: Integral with piping system service lettering to accommodate both directions; or as separate unit on each pipe marker to indicate direction of flow.
- F. Pre-tensioned Pipe Markers: Pre-coiled semi-rigid plastic formed to cover full circumference of pipe and to attach to pipe without adhesive.
- G. Shaped Pipe Markers: Preformed semi-rigid plastic formed to partially cover circumference of pipe and to attach to pipe with mechanical fasteners that do not penetrate insulation vapor barrier.
- H. Self-Adhesive Pipe Markers: Plastic with pressure-sensitive, permanent-type, self-adhesive back.
- I. Plastic Tape: Continuously printed, vinyl tape at least 3 mils (0.08 mm) thick with pressure-sensitive, permanent-type, self-adhesive back.
 - 1. Width for Markers on Pipes with OD, Including Insulation, Less Than 6 Inches (150 mm): 3/4 inch (19 mm) minimum.
 - 2. Width for Markers on Pipes with OD, Including Insulation, 6 Inches (150 mm) or Larger: 1-1/2 inches (38 mm) minimum.

2.3 VALVE TAGS

- A. Provide brass valve tags for all valves and a schedule under rigid plastic in the mechanical room.

2.4 WARNING TAGS

- A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags; of plasticized card stock with matte finish suitable for writing.
 - 1. Size: Approximately 4 by 7 inches (100 by 178 mm)
 - 2. Fasteners: Brass grommet and wire
 - 3. Nomenclature: Large-size primary caption such as DANGER, CAUTION, or DO NOT OPERATE.
 - 4. Color: Yellow background with black lettering.

PART 3 - EXECUTION**3.1 APPLICATIONS, GENERAL**

- A. Products specified are for applications referenced in other Division 23 Sections. If more than single-type material, device, or label is specified for listed applications, selection is Installer's option.

3.2 EQUIPMENT IDENTIFICATION

- A. Install and permanently fasten equipment nameplates on each major item of mechanical equipment that does not have nameplate or has nameplate that is damaged or located where not easily visible. Locate nameplates where accessible and visible. Include nameplates for the following general categories of equipment:
 - 1. Pumps, compressors, chillers, condensers, and similar motor-driven units.
 - 2. Heat exchangers, coils, evaporators, cooling towers, heat recovery units, and similar equipment.
 - 3. Fans.

3.3 PIPING AND DUCT IDENTIFICATION

- A. Install manufactured pipe markers indicating service on each piping system. Install with flow indication arrows showing direction of flow.
 - 1. Pipes with OD, Including Insulation, Less Than 6 Inches (150 mm): Pre-tensioned pipe markers: color-coded.
- B. Locate pipe markers and color bands where piping is exposed in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior nonconcealed locations as follows:
 - 1. Near each valve and control device.
 - 2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
 - 3. Near penetrations through walls, floors, ceilings, and nonaccessible enclosures.
 - 4. At access doors, manholes, and similar access points that permit view of concealed piping.
 - 5. Near major equipment items and other points of origination and termination.
 - 6. Spaced at maximum intervals of 50 feet (15 m) along each run. Reduce intervals to 25 feet (7.6 m) in areas of congested piping and equipment.
 - 7. On piping above removable acoustical ceilings. Omit intermediately spaced markers.

3.4 WARNING-TAG INSTALLATION

- A. Write required message on, and attach warning tags to, equipment and other items where required.

3.5 ADJUSTING

- A. Relocate mechanical identification materials and devices that have become visually blocked by other work.

3.6 CLEANING

- A. Clean faces of mechanical identification devices and glass frames of valve schedules.

END OF SECTION 23 05 53

SECTION 23 05 93 - TESTING, ADJUSTING, AND BALANCING FOR HVAC**PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

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

1.2 SUMMARY

- A. This Section includes TAB to produce design objectives for the following:
 - 1. Air Systems:
 - a. Constant-volume air systems.
 - b. Variable-air-volume systems.
 - 2. Hydronic Piping Systems:
 - a. Constant-flow systems.
 - b. Variable-flow systems.
 - 3. HVAC equipment quantitative-performance settings.
 - 4. Verifying that automatic control devices are functioning properly.
 - 5. Reporting results of activities and procedures specified in this Section.

1.3 SUBMITTALS

- A. Strategies and Procedures Plan: Within 90 days from Contractor's Notice to Proceed, submit two (2) copies of TAB strategies and step-by-step procedures as specified in Part 3 "Preparation" Article. Include a complete set of report forms intended for use on this Project.
- B. Certified TAB Reports: Submit two copies of reports prepared, as specified in this Section, on approved forms certified by TAB firm.
- C. Warranties specified in this Section.

1.4 QUALITY ASSURANCE

- A. TAB Firm Qualifications: Engage a TAB firm certified by AABC or NEBB.
- B. Certification of TAB Reports: Certify TAB field data reports. This certification includes the following:
 - 1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
 - 2. Certify that TAB team complied with approved TAB plan and the procedures specified and referenced in this Specification.
- C. TAB Report Forms: Use standard forms from AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems." Or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems."

1.5 PROJECT CONDITIONS

- A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.
- B. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

1.6 COORDINATION

- A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist TAB activities.
- B. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

1.7 WARRANTY

- A. National Project Performance Guarantee: Provide a guarantee on AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" forms stating that AABC will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents. Guarantee includes the following provisions:
 - 1. The certified TAB firm has tested and balanced systems according to the Contract Documents.
 - 2. Systems are balanced to optimum performance capabilities within design and installation limits.
- B. Special Guarantee: Provide a guarantee on NEBB forms stating that NEBB will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents. Guarantee shall include the following provisions:
 - 1. The certified TAB firm has tested and balanced systems according to the Contract Documents.
 - 2. Systems are balanced to optimum performance capabilities within design and installation limits.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.
 - 1. Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are required by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.
- B. Examine approved submittal data of HVAC systems and equipment.
- C. Examine Project Record Documents described in Division 01 Section "Project Record Documents."
- D. Examine design data, including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.
- E. Examine equipment performance data including fan and pump curves. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system. Calculate system effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from those presented when the equipment was performance tested at the factory. To calculate system effects for air

systems, use tables and charts found in AMCA 201, "Fans and Systems," Sections 7 through 10; or in SMACNA's "HVAC Systems--Duct Design," Sections 5 and 6. Compare this data with the design data and installed conditions.

- F. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Sections have been performed.
- G. Examine system and equipment test reports.
- H. Examine HVAC system and equipment installations to verify that indicated balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are properly installed, and that their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.
- I. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.
- J. Examine HVAC equipment to ensure that clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.
- K. Examine terminal units, such as variable-air-volume boxes, to verify that they are accessible and their controls are connected and functioning.
- L. Examine plenum ceilings used for supply air to verify that they are airtight. Verify that pipe penetrations and other holes are sealed.
- M. Examine strainers for clean screens and proper perforations.
- N. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.
- O. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
- P. Examine system pumps to ensure absence of entrained air in the suction piping.
- Q. Examine equipment for installation and for properly operating safety interlocks and controls.
- R. Examine automatic temperature system components to verify the following:
 - 1. Dampers, valves, and other controlled devices are operated by the intended controller.
 - 2. Dampers and valves are in the position indicated by the controller.
 - 3. Integrity of valves and dampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in multizone units, mixing boxes, and variable-air-volume terminals.
 - 4. Automatic modulating and shutoff valves, including two-way valves and three-way mixing and diverting valves, are properly connected.
 - 5. Thermostats and humidistats are located to avoid adverse effects of sunlight, drafts, and cold walls.
 - 6. Sensors are located to sense only the intended conditions.
 - 7. Sequence of operation for control modes is according to the Contract Documents.
 - 8. Controller set points are set at indicated values.
 - 9. Interlocked systems are operating.
 - 10. Changeover from heating to cooling mode occurs according to indicated values.
- S. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

- A. Prepare a TAB plan that includes strategies and step-by-step procedures.
- B. Complete system readiness checks and prepare system readiness reports. Verify the following:
 - 1. Permanent electrical power wiring is complete.
 - 2. Hydronic systems are filled, clean, and free of air.

3. Automatic temperature-control systems are operational.
4. Equipment and duct access doors are securely closed.
5. Balance, smoke, and fire dampers are open.
6. Isolating and balancing valves are open and control valves are operational.
7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
8. Windows and doors can be closed so indicated conditions for system operations can be met.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

- A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and this Section.
- B. Cut insulation, ducts and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to insulation Specifications for this Project.
- C. Mark equipment and balancing device settings with paint or other suitable, permanent identification material, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, to show final settings. Label circuit setters with final setting including flow and dP using a permanent metal tag.

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

- A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.
- B. Prepare schematic diagrams of systems' "as-built" duct layouts.
- C. For variable-air-volume systems, develop a plan to simulate diversity.
- D. Determine the best locations in main and branch ducts for accurate duct airflow measurements.
- E. Check airflow patterns from the outside-air louvers and dampers and the return- and exhaust-air dampers, through the supply-fan discharge and mixing dampers.
- F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
- G. Verify that motor starters are equipped with properly sized thermal protection.
- H. Check dampers for proper position to achieve desired airflow path.
- I. Check for airflow blockages.
- J. Check condensate drains for proper connections and functioning.
- K. Check for proper sealing of air-handling unit components.
- L. Check for proper sealing of air duct system.

3.5 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

- A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.
 1. Measure fan static pressures to determine actual static pressure as follows:
 - a. Measure outlet static pressure as far downstream from the fan as practicable and upstream from restrictions in ducts such as elbows and transitions.
 - b. Measure static pressure directly at the fan outlet or through the flexible connection.
 - c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from flexible connection and downstream from duct restrictions.

- d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.
 2. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.
 - a. Simulate dirty filter operation and record the point at which maintenance personnel must change filters.
 3. Measure static pressures entering and leaving other devices such as sound traps, heat recovery equipment, and air washers, under final balanced conditions.
 4. Compare design data with installed conditions to determine variations in design static pressures versus actual static pressures. Compare actual system effect factors with calculated system effect factors to identify where variations occur. Recommend corrective action to align design and actual conditions.
 5. Obtain approval from Architect for adjustment of fan speed higher or lower than indicated speed. Make required adjustments to pulley sizes, motor sizes, and electrical connections to accommodate fan-speed changes.
 6. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full cooling, full heating, economizer, and any other operating modes to determine the maximum required brake horsepower.
- B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows within specified tolerances.
 1. Measure static pressure at a point downstream from the balancing damper and adjust volume dampers until the proper static pressure is achieved.
 - a. Where sufficient space in submain and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.
 2. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.
- C. Measure terminal outlets and inlets without making adjustments.
 1. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.
- D. Adjust terminal outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using volume dampers rather than extractors and the dampers at air terminals.
 1. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.
2. Adjust patterns of adjustable outlets for proper distribution without drafts.

3.6 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

- A. Compensating for Diversity: When the total airflow of all terminal units is more than the indicated airflow of the fan, place a selected number of terminal units at a maximum set-point airflow condition until the total airflow of the terminal units equals the indicated airflow of the fan. Select the reduced airflow terminal units so they are distributed evenly among the branch ducts.
- B. Pressure-Independent, Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
 1. Set outside-air dampers at minimum, and return- and exhaust-air dampers at a position that simulates full-cooling load.
 2. Select the terminal unit that is most critical to the supply-fan airflow and static pressure. Measure static pressure. Adjust system static pressure so the entering static pressure for the critical terminal unit is not less than the sum of

- terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
3. Measure total system airflow. Adjust to within indicated airflow.
 4. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use terminal-unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units as described for constant-volume air systems.
 5. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow as described for constant-volume air systems.
 - a. If air outlets are out of balance at minimum airflow, report the condition but leave outlets balanced for maximum airflow.
 6. Remeasure the return airflow to the fan while operating at maximum return airflow and minimum outside airflow. Adjust the fan and balance the return-air ducts and inlets as described for constant-volume air systems.
 7. Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at the main supply-air sensing station to ensure that adequate static pressure is maintained at the most critical unit.
 8. Record the final fan performance data.

3.7 PROCEDURES FOR HYDRONIC SYSTEMS

- A. Measure water flow at pumps. Use the following procedures, except for positive-displacement pumps:
 1. Verify impeller size by operating the pump with the discharge valve closed. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
 2. Check system resistance. With all valves open, read pressure differential across the pump and mark pump manufacturer's head-capacity curve. Adjust pump discharge valve until indicated water flow is achieved.
 3. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on pump manufacturer's performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.
 4. Report flow rates that are not within plus or minus 5 percent of design.
- B. Set calibrated balancing valves, if installed, at calculated presettings.
- C. Measure flow at all stations and adjust, where necessary, to obtain first balance.
 1. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.
- D. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than indicated flow.
- E. Adjust balancing stations to within specified tolerances of indicated flow rate as follows:
 1. Determine the balancing station with the highest percentage over indicated flow.
 2. Adjust each station in turn, beginning with the station with the highest percentage over indicated flow and proceeding to the station with the lowest percentage over indicated flow.
 3. Record settings and mark balancing devices.
- F. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures including outdoor-air temperature.
- G. Measure the differential-pressure control valve settings existing at the conclusions of balancing.

3.8 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

- A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals and proceed as specified above for hydronic systems.

3.9 PROCEDURES FOR BOILERS

- A. Measure entering- and leaving-water temperatures and water flow.

3.10 PROCEDURES FOR HEAT-TRANSFER COILS

- A. Water Coils: Measure the following data for each coil:
 - 1. Entering- and leaving-water temperature.
 - 2. Water flow rate.
 - 3. Water pressure drop.
 - 4. Dry-bulb temperature of entering and leaving air.
 - 5. Wet-bulb temperature of entering and leaving air for cooling coils.
 - 6. Airflow.
 - 7. Air pressure drop.
 - 8. Calculate BTU transfer on both air side and water side.
- B. Electric-Heating Coils: Measure the following data for each coil:
 - 1. Nameplate data.
 - 2. Airflow.
 - 3. Entering- and leaving-air temperature at full load.
 - 4. Voltage and amperage input of each phase at full load and at each incremental stage.
 - 5. Calculated kilowatt at full load.
 - 6. Fuse or circuit-breaker rating for overload protection.
- C. Refrigerant Coils: Measure the following data for each coil:
 - 1. Dry-bulb temperature of entering and leaving air.
 - 2. Wet-bulb temperature of entering and leaving air.
 - 3. Airflow.
 - 4. Air pressure drop.
 - 5. Refrigerant suction pressure and temperature.

3.11 PROCEDURES FOR MOTORS

- A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:
 - 1. Manufacturer, model, and serial numbers.
 - 2. Motor horsepower rating.
 - 3. Motor rpm.
 - 4. Efficiency rating.
 - 5. Nameplate and measured voltage, each phase.
 - 6. Nameplate and measured amperage, each phase.
 - 7. Starter thermal-protection-element rating.
- B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass for the controller to prove proper operation. Record observations, including controller manufacturer, model and serial numbers, and nameplate data.

3.12 PROCEDURES FOR CONDENSING UNITS

- A. Verify proper rotation of fans.
- B. Measure entering- and leaving-air temperatures.
- C. Record compressor data.

- D. Refrigerant Coils: Measure the following data for each coil:
 - 1. Dry-bulb temperature of entering and leaving air.
 - 2. Wet-bulb temperature of entering and leaving air.
 - 3. Airflow.
 - 4. Air pressure drop.
 - 5. Refrigerant suction pressure and temperature.

3.13 PROCEDURES FOR TEMPERATURE MEASUREMENTS

- A. During TAB, report the need for adjustment in temperature regulation within the automatic temperature-control system.
- B. Measure indoor wet- and dry-bulb temperatures every other hour for a period of two successive eight-hour days, in each separately controlled zone, to prove correctness of final temperature settings. Measure when the building or zone is occupied.
- C. Measure outside-air, wet- and dry-bulb temperatures.

3.14 TEMPERATURE-CONTROL VERIFICATION

- A. Verify that controllers are calibrated and commissioned.
- B. Check transmitter and controller locations and note conditions that would adversely affect control functions.
- C. Record controller settings and note variances between set points and actual measurements.
- D. Check the operation of limiting controllers (i.e., high- and low-temperature controllers).
- E. Check free travel and proper operation of control devices such as damper and valve operators.
- F. Check the sequence of operation of control devices. Note air pressures and device positions and correlate with airflow and water flow measurements. Note the speed of response to input changes.
- G. Check the interaction of electrically operated switch transducers.
- H. Check the interaction of interlock and lockout systems.
- I. Check main control supply-air pressure and observe compressor and dryer operations.
- J. Record voltages of power supply and controller output. Determine whether the system operates on a grounded or nongrounded power supply.
- K. Note operation of electric actuators using spring return for proper fail-safe operations.

3.15 TOLERANCES

- A. Set HVAC system airflow and water flow rates within the following tolerances:
 - 1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus 5 to plus 10 percent.
 - 2. Air Outlets and Inlets: 0 to minus 10 percent.
 - 3. Heating-Water Flow Rate: 0 to minus 10 percent.

3.16 FINAL REPORT

- A. General: Typewritten, or computer printout in letter-quality font, on standard bond paper, in three-ring binder, tabulated and divided into sections by tested and balanced systems.
- B. Include a certification sheet in front of binder signed and sealed by the certified testing and balancing engineer.
 - 1. Include a list of instruments used for procedures, along with proof of calibration.
- C. Final Report Contents: In addition to certified field report data, include the following:
 - 1. Pump curves.
 - 2. Fan curves.
 - 3. Manufacturers' test data.
 - 4. Field test reports prepared by system and equipment installers.

5. Other information relative to equipment performance, but do not include Shop Drawings and Product Data.
- D. General Report Data: In addition to form titles and entries, include the following data in the final report, as applicable:
 1. Title page.
 2. Name and address of TAB firm.
 3. Project name.
 4. Project location.
 5. Architect's name and address.
 6. Engineer's name and address.
 7. Contractor's name and address.
 8. Report date.
 9. Signature of TAB firm who certifies the report.
 10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
 11. Summary of contents including the following:
 - a. Indicated versus final performance.
 - b. Notable characteristics of systems.
 - c. Description of system operation sequence if it varies from the Contract Documents.
 12. Nomenclature sheets for each item of equipment.
 13. Data for terminal units, including manufacturer, type size, and fittings.
 14. Notes to explain why certain final data in the body of reports varies from indicated values.
 15. Test conditions for fans and pump performance forms including the following:
 - a. Settings for outside-, return-, and exhaust-air dampers.
 - b. Conditions of filters.
 - c. Cooling coil, wet- and dry-bulb conditions.
 - d. Face and bypass damper settings at coils.
 - e. Fan drive settings including settings and percentage of maximum pitch diameter.
 - f. Inlet vane settings for variable-air-volume systems.
 - g. Settings for supply-air, static-pressure controller.
 - h. Other system operating conditions that affect performance.
- E. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:
 1. Quantities of outside, supply, return, and exhaust airflows.
 2. Water and steam flow rates.
 3. Duct, outlet, and inlet sizes.
 4. Pipe and valve sizes and locations.
 5. Terminal units.
 6. Balancing stations.
 7. Position of balancing devices.

3.17 ADDITIONAL TESTS

- A. Within 90 days of completing TAB, perform additional testing and balancing to verify that balanced conditions are being maintained throughout and to correct unusual conditions.
- B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional testing, inspecting, and adjusting during near-peak summer and winter conditions.

END OF SECTION 23 05 93

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SECTION 23 07 00 – HVAC PIPE INSULATION**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. Insulation Materials:
 - a. Flexible elastomeric
 - 2. Insulating cements.
 - 3. Adhesives.
 - 4. Mastics.
 - 5. Lagging adhesives.
 - 6. Sealants.
 - 7. Factory-applied jackets.
 - 8. Field-applied fabric-reinforcing mesh.
 - 9. Field-applied cloths.
 - 10. Field-applied jackets.
 - 11. Tapes.
 - 12. Securements.
 - 13. Corner angles.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated. Include thermal conductivity, thickness, and jackets (both factory and field applied, if any).
- B. Shop Drawings:
 - 1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
 - 2. Detail attachment and covering of heat tracing inside insulation.
 - 3. Detail insulation application at pipe expansion joints for each type of insulation.
 - 4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
 - 5. Detail removable insulation at piping specialties, equipment connections, and access panels.
 - 6. Detail application of field-applied jackets.
 - 7. Detail application at linkages of control devices.
 - 8. Detail field application for each equipment type.
- C. Qualification Data: For qualified Installer.
- D. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.
- E. Field quality-control reports.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.
- B. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing and inspecting agency.
 - 1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
 - 2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.6 COORDINATION

- A. Coordinate size and location of supports, hangers, and insulation shields specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."
- B. Coordinate clearance requirements with piping Installer for piping insulation application, duct Installer for duct insulation application, and equipment Installer for equipment insulation application. Before preparing piping and ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

1.7 SCHEDULING

- A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.
- B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

- A. Comply with requirements in Part 3 schedule articles for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.
- D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
- E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

- F. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.
 - 1. Products: Subject to compliance with requirements, provide the following:
 - a. Aeroflex USA Inc.; Aerocel.
 - b. Armacell LLC; AP Armaflex.
 - c. RBX Corporation; Insul-Sheet 1800 and Insul-Tube 180.

2.2 ADHESIVES

- A. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.
 - 1. Products: Subject to compliance with requirements, provide the following:
 - a. Aeroflex USA Inc.; Aero seal.
 - b. Armacell LCC; 520 Adhesive.
 - c. Foster Products Corporation, H. B. Fuller Company; 85-75.
 - d. RBX Corporation; Rubatex Contact Adhesive.

2.3 SEALANTS

- A. Joint Sealants:
 - 1. Joint Sealants for Polyisocyanurate Products: Subject to compliance with requirements, provide one of the following:
 - a. Childers Products, Division of ITW; CP-76.
 - b. Foster Products Corporation, H. B. Fuller Company; 30-45.
 - c. Marathon Industries, Inc.; 405.
 - d. Mon-Eco Industries, Inc.; 44-05.
 - e. Pittsburgh Corning Corporation; Pittseal 444.
 - f. Vimasco Corporation; 750.
 - 2. Materials shall be compatible with insulation materials, jackets, and substrates.
 - 3. Permanently flexible, elastomeric sealant.
 - 4. Service Temperature Range: Minus 100 to plus 300 deg F (Minus 73 to plus 149 deg C).
 - 5. Color: White or gray.

2.4 FIELD-APPLIED JACKETS

- A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.
- B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Johns Manville; Zeston.
 - b. P.I.C. Plastics, Inc.; FG Series.
 - c. Proto PVC Corporation; LoSmoke.
 - d. Speedline Corporation; SmokeSafe.
 - 2. Adhesive: As recommended by jacket material manufacturer.
 - 3. Color: Color-code jackets based on system. See Mechanical Identification Section for Color
 - 4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
 - a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.
 - 5. Factory-fabricated tank heads and tank side panels.
 - 6. Aluminum Jacket: Comply with ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105 or 5005, Temper H-14.
 - a. Sheet and roll stock ready for shop or field sizing.

- b. Finish and thickness are indicated in field-applied jacket schedules.
- c. Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper.
- d. Factory-Fabricated Fitting Covers:
 - 1) Same material, finish, and thickness as jacket.
 - 2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
 - 3) Tee covers.
 - 4) Flange and union covers.
 - 5) End caps.
 - 6) Beveled collars.
 - 7) Valve covers.
 - 8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

2.5 SECUREMENTS

- A. Bands:
 - 1. Aluminum: ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, 3/4 inch (19 mm) wide with closed seal.
 - 2. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.
- B. Insulation Pins and Hangers:
 - 1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch- (3.5-mm-) diameter shank, length to suit depth of insulation indicated.

2.6 CORNER ANGLES

- A. PVC Corner Angles: 30 mils (0.8 mm) thick, minimum 1 by 1 inch (25 by 25 mm), PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.
- B. Aluminum Corner Angles: 0.040 inch (1.0 mm) thick, minimum 1 by 1 inch (25 by 25 mm), aluminum according to ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105 or 5005; Temper H-14.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.
 - 1. Verify that systems and equipment to be insulated have been tested and are free of defects.
 - 2. Verify that surfaces to be insulated are clean and dry.
 - 3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- B. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment, ducts and fittings, and piping including fittings, valves, and specialties.
- B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment, duct system, and pipe system as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams between the 2 O'clock and 3 o'clock positions
- E. All joints shall be sealed weathertight and with appropriate UV resistant sealant for all exterior applications.
- F. Install multiple layers of insulation with longitudinal and end seams staggered.
- G. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- H. Keep insulation materials dry during application and finishing.
- I. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- J. Install insulation with least number of joints practical.
- K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- L. Install insulation with factory-applied jackets as follows:
 - 1. Draw jacket tight and smooth.
 - 2. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.
 - 3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches (50 mm) o.c.
 - a. For below ambient services, apply vapor-barrier mastic over staples.
 - 4. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.
- M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.
- P. For above ambient services, do not install insulation to the following:
 - 1. Vibration-control devices.
 - 2. Testing agency labels and stamps.
 - 3. Nameplates and data plates.
 - 4. Manholes.
 - 5. Handholes.
 - 6. Cleanouts.

3.4 PENETRATIONS

- A. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
 - 1. Seal penetrations with flashing sealant.
 - 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation,

- install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches (50 mm).
 4. Seal jacket to wall flashing with flashing sealant.
- B. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- C. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions. Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches (50 mm).
- D. Insulation Installation at Floor Penetrations:
1. Duct: Install insulation continuously through floor penetrations that are not fire rated. For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches (50 mm).
 2. Pipe: Install insulation continuously through floor penetrations.
 3. Seal penetrations through fire-rated assemblies.

3.5 GENERAL PIPE INSULATION INSTALLATION

- A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.
- B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:
1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity, unless otherwise indicated.
 2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
 3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
 4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
 5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below ambient services, provide a design that maintains vapor barrier.
 6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
 7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below ambient services and a breather mastic for

- above ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
 9. Stencil or label the outside insulation jacket of each union with the word "UNION." Match size and color of pipe labels.
- C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes, vessels, and equipment. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.
- D. Install removable insulation covers at locations indicated. Installation shall conform to the following:
1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
 2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
 3. Construct removable valve insulation covers in same manner as for flanges except divide the two-part section on the vertical center line of valve body.
 4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches (50 mm) over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
 5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.6 FLEXIBLE ELASTOMERIC INSULATION INSTALLATION

- A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- B. Insulation Installation on Pipe Flanges:
1. Install pipe insulation to outer diameter of pipe flange.
 2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
 3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
 4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- C. Insulation Installation on Pipe Fittings and Elbows:
1. Install mitered sections of pipe insulation.
 2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- D. Insulation Installation on Valves and Pipe Specialties:
1. Install preformed valve covers manufactured of same material as pipe insulation when available.

2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to

3.7 FIELD-APPLIED JACKET INSTALLATION

- A. Where PVC jackets are indicated, install with 1-inch (25-mm) overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.
 1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.
- B. Where metal jackets are indicated, install with 2-inch (50-mm) overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches (300 mm) o.c. and at end joints. Horizontal seams must also be sealed.

3.8 FINISHES

- A. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.
- B. Color: See Mechanical Identification Section for color. Vary first and second coats to allow visual inspection of the completed Work.
- C. Do not field paint aluminum or PVC jackets.

3.9 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 1. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.
- C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.10 INDOOR PIPING INSULATION SCHEDULE

- A. Condensate Drain Piping, From Condensate drain to receptor.
 1. Insulation shall be one of the following:
 - a. Flexible elastomeric. 3/4" thick.
- B. Refrigerant Suction and Hot-Gas Piping:
 1. Insulation shall be one of the following:
 - a. Flexible elastomeric. 2" Thick.

3.11 INDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

- B. If more than one material is listed, selection from materials listed is Contractor's option.
- C. Install removable jacketing for steam traps, PRVs, and all serviceable equipment.
- D. Piping, Concealed:
 - 1. None.
- E. Piping, Exposed Finished Areas:
 - 1. PVC, Color-Coded by System, 20 mils (0.5 mm) thick.
- F. Piping, Exposed Main Mechanical Room shall be one the following.
 - 1. PVC, Color-Coded by System, 20 mils (0.5 mm) thick.
- G. Equipment, Exposed Main Mechanical Room shall be;

3.12 MECHANICAL ROOM INSUALTION AND JACKETING

- A. All piping in mechanical rooms, under 8'0" shall be 2" thick with color coded 20 mil PVC jacket. Piping above 8'0 shall comply with sections above.

3.13 OUTDOOR PIPING INSULATION SCHEDULE

- A. Refrigerant Suction and Hot-Gas Piping:
 - 1. Insulation shall be one of the following:
 - a. Flexible elastomeric. 2" Thick.

3.14 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Refrigerant Suction and Hot-Gas Piping:
 - 1. Insulation shall be one of the following:
 - a. Aluminum jacket.

END OF SECTION 23 07 00

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SECTION 23 07 01 - HVAC DUCT INSULATION**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. Insulation Materials:
 - a. Mineral fiber.
 - 2. Fire-rated insulation systems.
 - 3. Insulating cements.
 - 4. Adhesives.
 - 5. Mastics.
 - 6. Factory-applied jackets.
 - 7. Field-applied fabric-reinforcing mesh.
 - 8. Tapes.
 - 9. Securements.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings:
 - 1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
 - 2. Detail attachment and covering of heat tracing inside insulation.
 - 3. Detail insulation application at pipe expansion joints for each type of insulation.
 - 4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
 - 5. Detail removable insulation at piping specialties, equipment connections, and access panels.
 - 6. Detail application of field-applied jackets.
 - 7. Detail application at linkages of control devices.
 - 8. Detail field application for each equipment type.
- C. Field quality-control reports.

1.4 QUALITY ASSURANCE

- A. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing and inspecting agency.
 - 1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
 - 2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

PART 2 - PRODUCTS**2.1 INSULATION MATERIALS**

- A. Lined ductwork shall not be accepted in any part of the system.
- B. Comply with requirements in Part 3 schedule articles for where insulating materials shall be applied.
- C. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- D. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.
- E. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
- F. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- G. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type III with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
 - 1. Products: Subject to compliance with requirements, provide the following:
 - a. CertainTeed Corp.; Duct Wrap.
 - b. Johns Manville; Microlite.
 - c. Knauf Insulation; Duct Wrap.
 - d. Manson Insulation Inc.; Alley Wrap.
 - e. Owens Corning; All-Service Duct Wrap.
- H. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
 - 1. Products: Subject to compliance with requirements, provide the following:
 - a. CertainTeed Corp.; Commercial Board.
 - b. Fibrex Insulations Inc.; FBX.
 - c. Johns Manville; 800 Series Spin-Glas.
 - d. Knauf Insulation; Insulation Board.
 - e. Manson Insulation Inc.; AK Board.
 - f. Owens Corning; Fiberglas 700 Series.

2.2 INSULATING CEMENTS

- A. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449/C 449M.
 - 1. Products: Subject to compliance with requirements, provide the following:
 - a. Insulco, Division of MFS, Inc.; SmoothKote.
 - b. P. K. Insulation Mfg. Co., Inc.; PK No. 127, and Quik-Cote.
 - c. Rock Wool Manufacturing Company; Delta One Shot.

2.3 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.
- B. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
 - 1. Products: Subject to compliance with requirements, provide the following:
 - a. Childers Products, Division of ITW; CP-82.
 - b. Foster Products Corporation, H. B. Fuller Company; 85-20.
 - c. ITW TACC, Division of Illinois Tool Works; S-90/80.
 - d. Marathon Industries, Inc.; 225.
 - e. Mon-Eco Industries, Inc.; 22-25.

2.4 MASTICS

- A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-C-19565C, Type II.
- B. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.
 - 1. Products: Subject to compliance with requirements, provide the following:
 - a. Childers Products, Division of ITW; CP-35.
 - b. Foster Products Corporation, H. B. Fuller Company; 30-90.
 - c. ITW TACC, Division of Illinois Tool Works; CB-50.
 - d. Marathon Industries, Inc.; 590.
 - e. Mon-Eco Industries, Inc.; 55-40.
 - f. Vimasco Corporation; 749.
 - 2. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm (0.009 metric perm) at 43-mil (1.09-mm) dry film thickness.
 - 3. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
 - 4. Solids Content: ASTM D 1644, 59 percent by volume and 71 percent by weight.
 - 5. Color: White.
- C. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.
 - 1. Products: Subject to compliance with requirements, provide the following:
 - a. Childers Products, Division of ITW; CP-10.
 - b. Foster Products Corporation, H. B. Fuller Company; 35-00.
 - c. ITW TACC, Division of Illinois Tool Works; CB-05/15.
 - d. Marathon Industries, Inc.; 550.
 - e. Mon-Eco Industries, Inc.; 55-50.
 - f. Vimasco Corporation; WC-1/WC-5.
 - 2. Water-Vapor Permeance: ASTM F 1249, 3 perms (2 metric perms) at 0.0625-inch (1.6-mm) dry film thickness.
 - 3. Service Temperature Range: Minus 20 to plus 200 deg F (Minus 29 to plus 93 deg C).
 - 4. Solids Content: 63 percent by volume and 73 percent by weight.
 - 5. Color: White.

2.5 FACTORY-APPLIED JACKETS

- A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
 - 1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
 - 2. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

2.6 FIELD-APPLIED FABRIC-REINFORCING MESH

- A. Woven Polyester Fabric: Approximately 1 oz./sq. yd. (34 g/sq. m) with a thread count of 10 strands by 10 strands/sq. inch (4 strands by 4 strands/sq. mm), in a Leno weave, for duct, equipment, and pipe.

2.7 FIELD-APPLIED JACKETS

- A. Aluminum Jacket: Comply with ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105 or 5005, Temper H-14.
 - 1. Sheet and roll stock ready for shop or field sizing.
 - 2. Finish and thickness are indicated in field-applied jacket schedules.

3. Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper.

2.8 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
 1. Products: Subject to compliance with requirements, provide the following:
 - a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0835.
 - b. Compac Corp.; 104 and 105.
 - c. Ideal Tape Co., Inc., an American Biltrite Company; 428 AWF ASJ.
 - d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.
 2. Width: 3 inches (75 mm).
 3. Thickness: 11.5 mils (0.29 mm).
 4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
 5. Elongation: 2 percent.
 6. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
 7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
 1. Products: Subject to compliance with requirements, provide the following:
 - a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
 - b. Compac Corp.; 110 and 111.
 - c. Ideal Tape Co., Inc., an American Biltrite Company; 491 AWF FSK.
 - d. Venture Tape; 1525 CW, 1528 CW, and 1528 CW/SQ.
 2. Width: 3 inches (75 mm).
 3. Thickness: 6.5 mils (0.16 mm).
 4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
 5. Elongation: 2 percent.
 6. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
 7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

2.9 SECUREMENTS

- A. Aluminum Bands: ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 3/4 inch (19 mm) wide with wing or closed seal.
 1. Products: Subject to compliance with requirements, provide the following:
 - a. Childers Products; Bands.
 - b. PABCO Metals Corporation; Bands.
 - c. RPR Products, Inc.; Bands.
- B. Insulation Pins and Hangers:
 1. Capacitor-discharge weld-pins: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - a. Products: Subject to compliance with requirements, provide the following:
 - 1) AGM Industries, Inc.; Tactoo Insul-Hangers, Series TSA.
 - 2) GEMCO; Press and Peel.
 - 3) Midwest Fasteners, Inc.; Self Stick.
 - b. Baseplate: Galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
 - c. Spindle: Copper- or zinc-coated, low carbon steel, fully annealed, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.

2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick, galvanized-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
 - a. Products: Subject to compliance with requirements, provide the following:
 - 1) AGM Industries, Inc.; RC-150.
 - 2) GEMCO; R-150.
 - 3) Midwest Fasteners, Inc.; WA-150.
 - 4) Nelson Stud Welding; Speed Clips.
 - b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
- C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- (19-mm-) wide, stainless steel or Monel.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- B. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.2 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment, ducts and fittings, and piping including fittings, valves, and specialties.
- B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment, duct system, and pipe system as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- G. Keep insulation materials dry during application and finishing.
- H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- I. Install insulation with least number of joints practical.
- J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 1. Install insulation continuously through hangers and around anchor attachments.
 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- L. Install insulation with factory-applied jackets as follows:
 1. Draw jacket tight and smooth.
 2. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.
 3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches (50 mm) o.c.
 - a. For below ambient services, apply vapor-barrier mastic over staples.
 4. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.
 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct and pipe flanges and fittings.
- M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.
- P. For above ambient services, do not install insulation to the following:
 1. Vibration-control devices.
 2. Testing agency labels and stamps.
 3. Nameplates and data plates.

3.3 PENETRATIONS

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
 1. Seal penetrations with flashing sealant.
 2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches (50 mm) below top of roof flashing.
 4. Seal jacket to roof flashing with flashing sealant.
- B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
 1. Seal penetrations with flashing sealant.
 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches (50 mm).
 4. Seal jacket to wall flashing with flashing sealant.
- C. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

- D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions. Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches (50 mm).
- E. Insulation Installation at Floor Penetrations:
 - 1. Duct: Install insulation continuously through floor penetrations that are not fire rated. For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches (50 mm).

3.4 SEAL PENETRATIONS THROUGH FIRE-RATED ASSEMBLIES.

3.5 MINERAL-FIBER INSULATION INSTALLATION

- A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
 - 1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
 - 2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
 - 3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. On duct sides with dimensions 18 inches (450 mm) and smaller, place pins along longitudinal centerline of duct. Space 3 inches (75 mm) maximum from insulation end joints, and 16 inches (400 mm) o.c.
 - b. On duct sides with dimensions larger than 18 inches (450 mm), place pins 16 inches (400 mm) o.c. each way, and 3 inches (75 mm) maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
 - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not overcompress insulation during installation.
 - e. Impale insulation over pins and attach speed washers.
 - f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
 - 4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches (50 mm) from 1 edge and 1 end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch (13-mm) outward-clinching staples, 1 inch (25 mm) o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
 - a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
 - b. Install vapor stops for ductwork and plenums operating below 50 deg F (10 deg C) at 18-foot (5.5-m) intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to 2 times the insulation thickness but not less than 3 inches (75 mm).

5. Overlap unfaced blankets a minimum of 2 inches (50 mm) on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches (450 mm) o.c.
 6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
 7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- (150-mm-) wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches (150 mm) o.c.
- B. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
 2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
 3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. On duct sides with dimensions 18 inches (450 mm) and smaller, place pins along longitudinal centerline of duct. Space 3 inches (75 mm) maximum from insulation end joints, and 16 inches (400 mm) o.c.
 - b. On duct sides with dimensions larger than 18 inches (450 mm), space pins 16 inches (400 mm) o.c. each way, and 3 inches (75 mm) maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
 - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not overcompress insulation during installation.
 - e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
 4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches (50 mm) from 1 edge and 1 end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch (13-mm) outward-clinching staples, 1 inch (25 mm) o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
 - a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
 - b. Install vapor stops for ductwork and plenums operating below 50 deg F (10 deg C) at 18-foot (5.5-m) intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to 2 times the insulation thickness but not less than 3 inches (75 mm).
 5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
 6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- (150-mm-) wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches (150 mm) o.c.

3.6 FIRE-RATED INSULATION SYSTEM INSTALLATION

- A. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.
- B. Insulate duct access panels and doors to achieve same fire rating as duct.
- C. Install firestopping at penetrations through fire-rated assemblies. Fire-stop systems are specified in Division 07 Section "Firestopping."

3.7 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. Inspect ductwork, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each duct system defined in the "Duct Insulation Schedule, General" Article.
 - 2. Inspect field-insulated equipment, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each type of equipment defined in the "Equipment Insulation Schedule" Article. For large equipment, remove only a portion adequate to determine compliance.
- C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.8 DUCT INSULATION SCHEDULE, GENERAL

- A. Plenums and Ducts Requiring Insulation:
 - 1. Indoor, concealed supply and outdoor air.
 - 2. Indoor, exposed supply and outdoor air.
 - 3. Indoor, concealed return located in nonconditioned space.
 - 4. Indoor, exposed return located in nonconditioned space.
 - 5. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
 - 6. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
 - 7. Outdoor, concealed supply and return.
 - 8. Outdoor, exposed supply and return.
- B. Items Not Insulated:
 - 1. Factory-insulated flexible ducts.
 - 2. Factory-insulated plenums and casings.
 - 3. Flexible connectors.
 - 4. Vibration-control devices.
 - 5. Factory-insulated access panels and doors.
 - 6. Exhaust Ducts

3.9 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

- A. Concealed, Supply-Air Duct and Plenum Insulation: Mineral-fiber blanket.
 - 1. Thermal insulation R-Value: R-8
 - 2. Factory FSK Jacket
- B. Concealed, Return-Air Duct and Plenum Insulation: Mineral-fiber blanket.
 - 1. Thermal insulation R-Value: R-8
 - 2. Factory FSK Jacket
- C. Concealed, Outdoor-Air Duct and Plenum Insulation: Mineral-fiber blanket.
 - 1. Thermal insulation R-Value: R-8
 - 2. Factory FSK Jacket
- D. Exposed, Supply-Air Duct and Plenum Insulation: Mineral-fiber board.

- 1. Thermal insulation R-Value: R-8
 - 2. Field-Applied Woven Fiber Jacket, painted.
- E. Exposed, Return-Air Duct and Plenum Insulation: Mineral-fiber board.
 - 1. Thermal insulation R-Value: R-8
 - 2. Field-Applied Woven Fiber Jacket, painted.
- F. Exposed, Outdoor-Air Duct and Plenum Insulation: Mineral-fiber board.
 - 1. Thermal insulation R-Value: R-8
 - 2. Field-Applied Woven Fiber Jacket, painted.

3.10 CONCEALED, ROOF-MOUNTED DUCT

- A. Supply duct
 - 1. Thermal insulation R-Value: R-8
 - 2. Double-walled construction with 2" mineral fiber preformed wrap.

END OF SECTION 23 07 01

SECTION 23 09 23 – GAS DETECTION 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 the Following Gas Instruments:
 - 1. Multipoint carbon-monoxide and NO2 monitoring system.

1.3 DEFINITIONS

- A. NDIR: Nondispersive infrared.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product, including the following:
 - 1. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
 - 2. Installation instructions, including factor affecting performance.
 - 3. Product description with complete technical data, performance curves, product specification sheets.
- B. Shop Drawings:
 - 1. Include plans, elevations, sections, and mounting heights.
 - 2. Include diagrams for power, signal, and control wiring.
 - 3. Number-coded identification system for unique identification of wiring, cable, and tubing ends.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plan drawings and corresponding product installation details, drawn to scale, on which wall-mounted instruments located in finished space are shown and coordinated with each other, showing relationship to light switches, fire alarm devices, and other installed devices using input from installers of the items involved.
- B. Product Test Reports: For each product, for tests performed by a qualified testing agency.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For gas instruments to include in operation and maintenance manuals.
- B. Certification report of as-built field testing.

PART 2 - PRODUCTS**2.1 MULTIPOINT CARBON-MONOXIDE MONITORING SYSTEM**

- A. Description:
 - 1. Each sampling point shall monitor any variation in the carbon-monoxide concentration level.
 - 2. Each sampling point shall be an alarm point.
 - 3. Sample time shall be adjustable in 1 second increments from zero to 60 minutes.
 - 4. Span and zero calibration gas shall be automatically initiated by the microprocessor. System shall also provide manual initiation of span and zero calibration gas.
 - 5. Analyzer output shall be corrected by the microprocessor.
 - 6. System shall operate on 120-V ac, single-phase, 60-Hz power.
 - 7. Final adjustment; calibration, testing, and startup of the system shall be performed by a trained representative of manufacturer.
- B. Analyzer:
 - 1. Analyzer shall operate using principle of nondispersive infrared absorption.
 - 2. Sampling response time shall be within 10 seconds.
 - 3. Zero drift and span drift shall be less than 1 percent of full scale within a 24-hour period.
 - 4. Repeatability shall be within 1 percent of full scale.
 - 5. Accuracy shall be within 1 percent of full scale.
 - 6. Calibration range shall be zero to 500 ppm.
 - 7. Digital display on analyzer face with scale shall be in ppm.
 - 8. Temperature shall be compensated from 30 to 120 deg F (minus 1 to 49 deg C) ambient temperature.
- C. Control and Display:
 - 1. Each sample shall send a 4-20 mA output signal proportional to the highest concentration.
 - 2. Alphanumeric visual display of current analyzer concentration reading shall be in ppm or another industry-accepted measurement.
 - 3. Visual indication for sample analyzing, sample high-concentration alarm, analyzer malfunction, and calibration.
 - 4. Each sample point shall be capable of being manually sampled through an override feature.
 - 5. System parameters shall be stored in nonvolatile memory.
 - 6. Provide at least an eight-hour battery backup of current alarm status. Battery shall be rechargeable.
- D. Enclosure:
 - 1. NEMA 250, Type 1
 - 2. Hinged and locking door, full size of face.
 - 3. House all system components. Multiple adjoining enclosures are acceptable if joined to a common support structure.
 - 4. Sensors mounted below 8ft shall be protected with lockable wire guard.
- E. Calibration Equipment:
 - 1. Provide equipment necessary to automatically and manually calibrate the system, including, but not be limited to, the following:
 - a. Regular assembly.
 - b. Zero cap.
 - c. Calibration cap.
 - d. Two cylinders filled with calibration gas.
 - e. Instruction book.
 - f. Carrying case.

PART 3 - EXECUTION**3.1 EXAMINATION**

- A. Examine substrates 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 instruments installed in piping to verify actual locations of connections before installation.
- C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.
- D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

- A. Furnish and install products required to satisfy more stringent of all requirements indicated.
- B. Install products level, plumb, parallel, and perpendicular with building construction.
- C. Properly support instruments, tubing, piping, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to seismic loads.
- D. Fastening Hardware:
 - 1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
 - 2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by using excessive force or oversized wrenches.
 - 3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.
- E. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

3.3 ELECTRICAL POWER

- A. Furnish and install electrical power to products requiring electrical connections.
- B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."
- C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.4 INSTRUMENTS, GENERAL INSTALLATION REQUIREMENTS

- A. Mounting Location:
 - 1. Install transmitters for gas associated with individual air-handling units and associated connected ductwork and piping near air-handlings units co-located in air-handling unit system control panel, to provide service personnel a single and convenient location for inspection and service.
 - 2. Install gas switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
 - 3. Mount switches and transmitters not required to be mounted within system control panels on walls, floor-supported freestanding pipe stands, or floor-supported structural support

- frames. Use manufacturer's mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.
4. Install instruments in dry gas and non-condensable vapor piped services above their process connection point. Slope process connection lines up to instrument with a minimum slope of [2] [3] <Insert number> percent.
- B. Mounting Height:
1. Mount instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.
 2. Mount switches and transmitters located in mechanical equipment rooms and other similar space not subject to code, state, and federal accessibility requirements within a range of 42 to 72 inches (1.1 to 1.6 m) above the adjacent floor, grade, or service catwalk or platform.
 - a. Make every effort to mount at 60 inches (1.5 m).
- C. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated, using neoprene gaskets or grommets.

3.5 CARBON-MONOXIDE MONITORING SYSTEM

- A. Install sample points in monitored area to provide accurate measurement of gas concentration.
- B. Install exposed sampling points with a finished appearance consistent with other materials in space. Submit proposed products to be installed for review and approval.
- C. Individually install each sample point to the carbon-monoxide monitoring system.
- D. Locate carbon-monoxide monitoring system in a secured and serviceable location accessible to authorized personnel in accordance with manufacturer requirements.
- E. Support carbon-monoxide monitoring system from floor or wall.

3.6 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- B. Install engraved phenolic nameplate with instrument identification on face.

3.7 CHECKOUT PROCEDURES

- A. Check out installed products before continuity tests, leak tests, and calibration.
- B. Check instruments for proper location and accessibility.
- C. Check instruments for proper installation on direction of flow, elevation, orientation, insertion depth, or other applicable considerations that impact performance.

3.8 ADJUSTMENT, CALIBRATION, AND TESTING

- A. Description:
 1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
 2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
 3. For each analog instrument, perform a three-point calibration test for both linearity and accuracy.

4. Equipment and procedures used for calibration shall comply with instrument manufacturer's written recommendations.
 5. Provide diagnostic and test equipment for calibration and adjustment.
 6. Field instruments and equipment used to test and calibrate installed instruments shall have an accuracy of at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.
 7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
 8. If, after calibration, indicated performance cannot be achieved, replace out-of-tolerance instruments.
 9. Comply with field-testing requirements and procedures in ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.
- B. Meters: Check sensors at zero, 50, and 100 percent of Project design values.
- C. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.
- D. Switches: Calibrate switches to make or break contact at set points indicated.
- E. Transmitters:
1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
 2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistance source.

3.9 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.
- B. Coordinate gas instrument demonstration video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.

END OF SECTION 23 09 23

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SECTION 23 23 00 - REFRIGERANT PIPING**PART 1 - GENERAL****1.1 SUMMARY**

- A. This Section includes refrigerant piping used for air-conditioning applications.

1.2 PERFORMANCE REQUIREMENTS

- A. Line Test Pressure for Refrigerant R-454B & R32:
 - 1. Suction Lines for Air-Conditioning Applications: 300 psig.
 - 2. Suction Lines for Heat-Pump Applications: 535 psig.
 - 3. Hot-Gas and Liquid Lines: 535 psig.

1.3 SUBMITTALS

- A. Product Data: For each type of valve and refrigerant piping specialty indicated. Include pressure drop based on manufacturer's test data.
- B. Shop Drawings: Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes, flow capacities, valve arrangements and locations, slopes of horizontal runs, oil traps, double risers, wall and floor penetrations, and equipment connection details. Show interface and spatial relationships between piping and equipment.
 - 1. Refrigerant piping indicated on Drawings is schematic only. Size piping and design actual piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.
- C. Field quality-control test reports.
- D. Operation and maintenance data.

1.4 QUALITY ASSURANCE

- A. Comply with ASHRAE 15-2022, "Safety Code for Refrigeration Systems."
- B. Comply with ASHRAE 34-2022, "Designation and Safety Classification of Refrigerants."
- C. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.5 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.

PART 2 - PRODUCTS**2.1 COPPER TUBE AND FITTINGS**

- A. Copper Tube: ASTM B 88, Type K or L (ASTM B 88M, Type A or B).
- B. Wrought-Copper Fittings: ASME B16.22.
- C. Wrought-Copper Unions: ASME B16.22.
- D. Solder Filler Metals: ASTM B 32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.
- E. Brazing Filler Metals: AWS A5.8.
- F. Flexible Connectors:

1. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
2. End Connections: Socket ends.
3. Offset Performance: Capable of minimum 3/4-inch (20-mm) misalignment in minimum 7-inch- (180-mm-) long assembly.
4. Pressure Rating: Factory test at minimum 500 psig (3450 kPa).
5. Maximum Operating Temperature: 250 deg F (121 deg C).

2.2 VALVES AND SPECIALTIES

- A. Diaphragm Packless Valves:
 1. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.
 2. Diaphragm: Phosphor bronze and stainless steel with stainless-steel spring.
 3. Operator: Rising stem and hand wheel.
 4. Seat: Nylon.
 5. End Connections: Socket, union, or flanged.
 6. Working Pressure Rating: 500 psig (3450 kPa).
 7. Maximum Operating Temperature: 275 deg F (135 deg C).
- B. Packed-Angle Valves:
 1. Body and Bonnet: Forged brass or cast bronze.
 2. Packing: Molded stem, back seating, and replaceable under pressure.
 3. Operator: Rising stem.
 4. Seat: Nonrotating, self-aligning polytetrafluoroethylene.
 5. Seal Cap: Forged-brass or valox hex cap.
 6. End Connections: Socket, union, threaded, or flanged.
 7. Working Pressure Rating: 500 psig (3450 kPa).
 8. Maximum Operating Temperature: 275 deg F (135 deg C).
- C. Check Valves:
 1. Body: Ductile iron, forged brass, or cast bronze; globe pattern.
 2. Bonnet: Bolted ductile iron, forged brass, or cast bronze; or brass hex plug.
 3. Piston: Removable polytetrafluoroethylene seat.
 4. Closing Spring: Stainless steel.
 5. Manual Opening Stem: Seal cap, plated-steel stem, and graphite seal.
 6. End Connections: Socket, union, threaded, or flanged.
 7. Maximum Opening Pressure: 0.50 psig (3.4 kPa).
 8. Working Pressure Rating: 500 psig (3450 kPa).
 9. Maximum Operating Temperature: 275 deg F (135 deg C).
- D. Service Valves:
 1. Body: Forged brass with brass cap including key end to remove core.
 2. Core: Removable ball-type check valve with stainless-steel spring.
 3. Seat: Polytetrafluoroethylene.
 4. End Connections: Copper spring.
 5. Working Pressure Rating: 500 psig (3450 kPa).
- E. Solenoid Valves: Comply with ARI 760 and UL 429; listed and labeled by an NRTL.
 1. Body and Bonnet: Plated steel.
 2. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
 3. Seat: Polytetrafluoroethylene.
 4. End Connections: Threaded.
 5. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch (16-GRC) conduit adapter, and 115-V ac coil.
 6. Working Pressure Rating: 400 psig (2760 kPa).
 7. Maximum Operating Temperature: 240 deg F (116 deg C).
 8. Manual operator.
- F. Safety Relief Valves: Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.

1. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
2. Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Seat Disc: Polytetrafluoroethylene.
4. End Connections: Threaded.
5. Working Pressure Rating: 400 psig (2760 kPa).
6. Maximum Operating Temperature: 240 deg F (116 deg C).
- G. Thermostatic Expansion Valves: Comply with ARI 750.
 1. Body, Bonnet, and Seal Cap: Forged brass or steel.
 2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
 3. Packing and Gaskets: Non-asbestos.
 4. Capillary and Bulb: Copper tubing filled with refrigerant charge.
 5. Suction Temperature: 40 deg F (4.4 deg C)].
 6. Superheat: Adjustable.
 7. Reverse-flow option (for heat-pump applications).
 8. End Connections: Socket, flare, or threaded union.
 9. Working Pressure Rating: 700 psig (4820 kPa).
- H. Straight-Type Strainers:
 1. Body: Welded steel with corrosion-resistant coating.
 2. Screen: 100-mesh stainless steel.
 3. End Connections: Socket or flare.
 4. Working Pressure Rating: 500 psig (3450 kPa).
 5. Maximum Operating Temperature: 275 deg F (135 deg C).
- I. Angle-Type Strainers:
 1. Body: Forged brass or cast bronze.
 2. Drain Plug: Brass hex plug.
 3. Screen: 100-mesh monel.
 4. End Connections: Socket or flare.
 5. Working Pressure Rating: 500 psig (3450 kPa).
 6. Maximum Operating Temperature: 275 deg F (135 deg C).
- J. Moisture/Liquid Indicators:
 1. Body: Forged brass.
 2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
 3. Indicator: Color coded to show moisture content in ppm.
 4. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
 5. End Connections: Socket or flare.
 6. Working Pressure Rating: 500 psig (3450 kPa).
 7. Maximum Operating Temperature: 240 deg F (116 deg C).
- K. Replaceable-Core Filter Dryers: Comply with ARI 730.
 1. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
 2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
 3. Desiccant Media: Activated charcoal.
 4. Designed for reverse flow (for heat-pump applications).
 5. End Connections: Socket.
 6. Access Ports: NPS 1/4 (DN 8) connections at entering and leaving sides for pressure differential measurement.
 7. Maximum Pressure Loss: 2 psig (14 kPa).
 8. Rated Flow: Matched to Unit.
 9. Working Pressure Rating: 500 psig (3450 kPa).
 10. Maximum Operating Temperature: 240 deg F (116 deg C).
- L. Permanent Filter Dryers: Comply with ARI 730.
 1. Body and Cover: Painted-steel shell.
 2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
 3. Desiccant Media: Activated charcoal.
 4. Designed for reverse flow (for heat-pump applications).

5. End Connections: Socket.
 6. Access Ports: NPS 1/4 (DN 8) connections at entering and leaving sides for pressure differential measurement.
 7. Maximum Pressure Loss: 2 psig (14 kPa).
 8. Rated Flow: Matched to Unit.
 9. Working Pressure Rating: 500 psig (3450 kPa).
 10. Maximum Operating Temperature: 240 deg F (116 deg C).
- M. Liquid Accumulators: Comply with ARI 495.
1. Body: Welded steel with corrosion-resistant coating.
 2. End Connections: Socket or threaded.
 3. Working Pressure Rating: 500 psig (3450 kPa).
 4. Maximum Operating Temperature: 275 deg F (135 deg C).

2.3 REFRIGERANTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Atofina Chemicals, Inc.
 2. DuPont Company; Fluorochemicals Div.
 3. Honeywell, Inc.; Genetron Refrigerants.
 4. INEOS Fluor Americas LLC.
- B. R454B
- C. R32

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

- A. Suction Lines for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.
- B. Safety-Relief-Valve Discharge Piping: Copper, Type L (B), drawn-temper tubing and wrought-copper fittings with soldered joints.

3.2 VALVE AND SPECIALTY APPLICATIONS

- A. Install packed-angle valves in suction and discharge lines of compressor.
- B. Install service valves for gage taps at strainers if they are not an integral part of strainers.
- C. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.
- D. Except as otherwise indicated, install packed-angle valves on inlet and outlet side of filter dryers.
- E. Install a full-sized, three-valve bypass around filter dryers.
- F. Install solenoid valves upstream from each expansion valve. Install solenoid valves in horizontal lines with coil at top.
- G. Install thermostatic expansion valves as close as possible to distributors on evaporators.
1. Install valve so diaphragm case is warmer than bulb.
 2. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.
 3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.
- H. Install safety relief valves where required by ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.
- I. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.

- J. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for device being protected:
 - 1. Solenoid valves.
 - 2. Thermostatic expansion valves.
 - 3. Compressor.
- K. Install filter dryers in liquid line between compressor and thermostatic expansion valve.
- L. Install flexible connectors at compressors.

3.3 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 calculate friction loss, expansion, pump sizing, 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 and bends.
- H. Install fittings for changes in direction and branch connections.
- I. Select system components with pressure rating equal to or greater than system operating pressure.
- J. Refer to Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operations for HVAC Controls" for solenoid valve controllers, control wiring, and sequence of operation.
- K. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.
- L. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties 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.
- N. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.
- O. Slope refrigerant piping as follows:
 - 1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
 - 2. Install horizontal suction lines with a uniform slope downward to compressor.
 - 3. Install traps and double risers to entrain oil in vertical runs.
 - 4. Liquid lines may be installed level.
- P. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.
- Q. Install pipe sleeves at penetrations in exterior walls and floor assemblies.
- R. Seal penetrations through fire and smoke barriers according to Division 07 Section "Penetration Firestopping."
- S. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.
- T. Install sleeves through floors, walls, or ceilings, sized to permit installation of full-thickness insulation.
- U. Seal pipe penetrations through exterior walls according to Division 07 Section "Joint Sealants" for materials and methods.

- V. Identify refrigerant piping and valves according to Division 23 Section "Identification for HVAC Piping and Equipment."

3.4 PIPE JOINT CONSTRUCTION

- A. Soldered Joints: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook."
- B. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."
 - 1. Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper pipe.
 - 2. Use Type BAg, cadmium-free silver alloy for joining copper with bronze or steel.

3.5 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:
 - 1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet (6 m) long.
 - 2. Roller hangers and spring hangers for individual horizontal runs 20 feet (6 m) or longer.
 - 3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet (6 m) or longer, supported on a trapeze.
 - 4. Spring hangers to support vertical runs.
 - 5. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
- C. Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:
 - 1. NPS 1/2 (DN 15): Maximum span, 60 inches (1500 mm); minimum rod size, 1/4 inch (6.4 mm).
 - 2. NPS 5/8 (DN 18): Maximum span, 60 inches (1500 mm); minimum rod size, 1/4 inch (6.4 mm).
 - 3. NPS 1 (DN 25): Maximum span, 72 inches (1800 mm); minimum rod size, 1/4 inch (6.4 mm).
 - 4. NPS 1-1/4 (DN 32): Maximum span, 96 inches (2400 mm); minimum rod size, 3/8 inch (9.5 mm).
 - 5. NPS 1-1/2 (DN 40): Maximum span, 96 inches (2400 mm); minimum rod size, 3/8 inch (9.5 mm).
 - 6. NPS 2 (DN 50): Maximum span, 96 inches (2400 mm); minimum rod size, 3/8 inch (9.5 mm).
 - 7. NPS 2-1/2 (DN 65): Maximum span, 108 inches (2700 mm); minimum rod size, 3/8 inch (9.5 mm).
 - 8. NPS 3 (DN 80): Maximum span, 10 feet (3 m); minimum rod size, 3/8 inch (9.5 mm).
 - 9. NPS 4 (DN 100): Maximum span, 12 feet (3.7 m); minimum rod size, 1/2 inch (13 mm).
- D. Support multifloor vertical runs at least at each floor.

3.6 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
- B. Tests and Inspections:
 - 1. Comply with ASME B31.5, Chapter VI.
 - 2. Test refrigerant piping and specialties. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.

3. Test high- and low-pressure side 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.

3.7 SYSTEM CHARGING

- A. Charge system using the following procedures:
 1. Install core in filter dryers after leak test but before evacuation.
 2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers (67 Pa). If vacuum holds for 12 hours, system is ready for charging.
 3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig (14 kPa).
 4. Charge system with a new filter-dryer core in charging line.

3.8 ADJUSTING

- A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.
- B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.
- C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.
- D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:
 1. Open shutoff valves in condenser water circuit.
 2. Verify that compressor oil level is correct.
 3. Open compressor suction and discharge valves.
 4. Open refrigerant valves except bypass valves that are used for other purposes.
 5. Check open compressor-motor alignment and verify lubrication for motors and bearings.
- E. Replace core or replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION 23 23 00

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SECTION 23 31 13 - METAL DUCTS**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. Single-wall rectangular ducts and fittings.
 - 2. Double-wall ducts and fittings in inaccessible locations.
 - 3. Double-wall ducts and fittings for sound attenuation
 - 4. Single-wall round and flat-oval ducts and fittings.
 - 5. Sheet metal materials.
 - 6. Duct liner (not permitted)
 - 7. Sealants and gaskets.
 - 8. Hangers and supports.
 - 9. Seismic-restraint devices.
- B. Related Sections:
 - 1. Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
 - 2. Division 23 Section "Nonmetal Ducts" for fibrous-glass ducts, thermoset fiber-reinforced plastic ducts, thermoplastic ducts, PVC ducts, and concrete ducts.
 - 3. Division 23 Section "HVAC Casings" for factory- and field-fabricated casings for mechanical equipment.
 - 4. Division 23 Section "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.3 PERFORMANCE REQUIREMENTS

- A. Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated.
 - 1. Static-Pressure Classes:
 - a. Supply Ducts (except in Mechanical Rooms): 1-inch wg (250 Pa)
 - b. Supply Ducts (Upstream from Air Terminal Units): 2-inch wg (500 Pa)
 - c. Supply Ducts (Downstream from Air Terminal Units): 1-inch wg (250 Pa)
 - d. Supply Ducts (in Mechanical Equipment Rooms): 2-inch wg (500 Pa)
 - e. Return Ducts (Negative Pressure): 1-inch wg (250 Pa)
 - f. Exhaust Ducts (Negative Pressure): 1-inch wg (250 Pa)
 - 2. Leakage Class:
 - a. Round Supply-Air Duct: 3 cfm/100 sq. ft. at 1-inch wg (0.14 L/s per sq. m at 250 Pa)
 - b. Rectangular Supply-Air Duct: 6 cfm/100 sq. ft. at 1-inch wg (0.29 L/s per sq. m at 250 Pa)
 - c. Flexible Supply-Air Duct: 6 cfm/100 sq. ft. at 1-inch wg (0.29 L/s per sq. m at 250 Pa) Retain seismic options and design criteria in paragraph below that are approved by authorities having jurisdiction.

1.4 SUBMITTALS

- A. Product Data: For each type of the following products:
 - 1. Sealants and gaskets.
- B. Shop Drawings:
 - 1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
 - 2. Factory- and shop-fabricated ducts and fittings.
 - 3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
 - 4. Elevation of top of ducts.
 - 5. Dimensions of main duct runs from building grid lines.
 - 6. Fittings.
 - 7. Reinforcement and spacing.
 - 8. Seam and joint construction.
 - 9. Penetrations through fire-rated and other partitions.
 - 10. Equipment installation based on equipment being used on Project.
 - 11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
 - 12. Hangers and supports, including methods for duct and building attachment
- C. 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. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
 - 2. Suspended ceiling components.
 - 3. Structural members to which duct will be attached.
 - 4. Size and location of initial access modules for acoustical tile.
 - 5. Penetrations of smoke barriers and fire-rated construction.
 - 6. Items penetrating finished ceiling including the following:
 - a. Lighting fixtures.
 - b. Air outlets and inlets.
 - c. Speakers.
 - d. Sprinklers.
 - e. Access panels.
 - f. Perimeter moldings.
 - g. Other requirements for coordination drawings provided in SECTION 230010 – COORDINATION DRAWINGS
- D. Welding certificates.
- E. Field quality-control reports.

1.5 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel according to the following:
 - 1. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.
- B. Mockups:
 - 1. Before installing duct systems, build mockups representing roof chase enclosed ductwork. Build mockup to comply with the following requirements, using materials indicated for the completed Work:
 - a. Two transverse joints.
 - b. One typical branch connection, each with at least one elbow.
 - c. One 90-degree turn with turning vanes.
 - d. Perform leakage tests specified in "Field Quality Control" Article. Revise mockup construction and perform additional tests as required to achieve specified minimum acceptable results.

2. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.
- C. Duct performance shall be demonstrated to engineer and owner for all new ductwork installed to be in compliance with requirements above.
 1. Leakage test shall be a dual-manometer type.
 2. Leakage rates shall be calculated by contractor based upon fan curves
 3. No new ductwork may be insulated until leakage test has been performed and approved by engineer.

PART 2 - PRODUCTS

2.1 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.
- B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-4, "Transverse (Girth) Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-5, "Longitudinal Seams - Rectangular Ducts," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 2, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.2 DOUBLE-WALL DUCTS AND FITTINGS IN INACCESSIBLE LOCATIONS:

- A. Fabricate ducts with indicated dimensions for the inner duct.
- B. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.
- C. Transverse Joints: Welded Joints
- D. Longitudinal Seams: Welded Joints
- E. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
 1. Maximum Thermal Conductivity: 0.27 Btu x in./h x sq. ft. x deg F (0.039 W/m x K)] at 75 deg F (24 deg C) mean temperature.
 2. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
 3. Coat insulation with antimicrobial coating.
 4. Cover insulation with polyester film complying with UL 181, Class 1.
- F. Inner Duct – In-accessible applications: solid sheet steel.

2.3 DOUBLE-WALL DUCTS AND FITTINGS FOR SOUND ATTENUATION

- A. Rectangular Ducts: Fabricate ducts with indicated dimensions for the inner duct.
- B. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

- C. Formed-on Transverse Joints (Flanges): Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-4, "Traverse (Girth) Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- D. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-5, "Longitudinal Seams - Rectangular Ducts," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- E. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
 - 1. Maximum Thermal Conductivity: 0.27 Btu x in./h x sq. ft. x deg F (0.039 W/m x K)] at 75 deg F (24 deg C) mean temperature.
 - 2. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
 - 3. Coat insulation with antimicrobial coating.
 - 4. Cover insulation with polyester film complying with UL 181, Class 1.
- F. Inner Duct – Sound Attenuation Applications: Minimum 0.028-inch (0.7-mm) perforated galvanized sheet steel having 3/32-inch- (2.4-mm-) diameter perforations, with overall open area of 23 percent

2.4 SINGLE-WALL ROUND AND FLAT-OVAL DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.
- B. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter (diameter of the round sides connecting the flat portions of the duct).
- C. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Transverse Joints - Round Duct," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 1. Transverse Joints in Ducts Larger Than 60 Inches (1524 mm) in Diameter: Flanged.
- D. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Seams - Round Duct and Fittings," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 1. Fabricate round ducts larger than 90 inches (2286 mm) in diameter with butt-welded longitudinal seams.
 - 2. Fabricate flat-oval ducts larger than 72 inches (1830 mm) in width (major dimension) with butt-welded longitudinal seams.
- E. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.5 SHEET METAL MATERIALS

- A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct

construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

- B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
 - 1. Galvanized Coating Designation: G60 (Z180)
 - 2. Finishes for Surfaces Exposed to View: Mill phosphatized.
- C. Carbon-Steel Sheets: Comply with ASTM A 1008/A 1008M, with oiled, matte finish for exposed ducts.
- D. Factory- or Shop-Applied Antimicrobial Coating:
 - 1. Apply to the surface of sheet metal that will form the interior surface of the duct. An untreated clear coating shall be applied to the exterior surface.
 - 2. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
 - 3. Coating containing the antimicrobial compound shall have a hardness of 2H, minimum, when tested according to ASTM D 3363.
 - 4. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
 - 5. Shop-Applied Coating Color: Black.
 - 6. Antimicrobial coating on sheet metal is not required for duct containing liner treated with antimicrobial coating.
- E. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
 - 1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.
- F. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

2.6 DUCT LINER

- 1. Duct liner will not be accepted in any part of the system for this project.

2.7 SEALANT AND GASKETS

- A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
- B. Two-Part Tape Sealing System:
 - 1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
 - 2. Tape Width: 4 inches (102 mm).
 - 3. Sealant: Modified styrene acrylic.
 - 4. Water resistant.
 - 5. Mold and mildew resistant.
 - 6. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive and negative.
 - 7. Service: Indoor and outdoor.
 - 8. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).
 - 9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.
- C. Water-Based Joint and Seam Sealant:
 - 1. Application Method: Brush on.
 - 2. Solids Content: Minimum 65 percent.
 - 3. Shore A Hardness: Minimum 20.
 - 4. Water resistant.

5. Mold and mildew resistant.
 6. VOC: Maximum 75 g/L (less water).
 7. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive and negative.
 8. Service: Indoor or outdoor.
 9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.
- D. Flanged Joint Sealant: Comply with ASTM C 920.
1. General: Single-component, acid-curing, silicone, elastomeric.
 2. Type: S.
 3. Grade: NS.
 4. Class: 25.
 5. Use: O.
- E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.
- F. Round Duct Joint O-Ring Seals:
1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg (0.14 L/s per sq. m at 250 Pa) and shall be rated for 10-inch wg (2500-Pa) static-pressure class, positive or negative.
 2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
 3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.8 HANGERS AND SUPPORTS

- A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.
- B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
- C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 4-1 (Table 4-1M), "Rectangular Duct Hangers Minimum Size," and Table 4-2, "Minimum Hanger Sizes for Round Duct."
- D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.
- E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.
- F. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.
- G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- H. Trapeze and Riser Supports:
1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
 2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
 3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.
- B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

- C. Install round and flat-oval ducts in maximum practical lengths.
- D. Install ducts with fewest possible joints.
- E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.
- F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
- G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- H. Install ducts with a clearance of 1 inch (25 mm), plus allowance for insulation thickness.
- I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.
- J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches (38 mm).
- K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Division 23 Section "Air Duct Accessories" for fire and smoke dampers.
- L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "Duct Cleanliness for New Construction Guidelines."

3.2 SEAM AND JOINT SEALING

- A. Seal duct seams and joints for duct static-pressure and leakage classes specified in "Performance Requirements" Article, according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 1-2, "Standard Duct Sealing Requirements," unless otherwise indicated.
- B. Seal Classes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 1-2, "Standard Duct Sealing Requirements."

3.3 HANGER AND SUPPORT INSTALLATION

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Hangers and Supports."
- B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
 - 1. Where practical, install concrete inserts before placing concrete.
 - 2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
 - 3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches (100 mm) thick.
 - 4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches (100 mm) thick.
 - 5. Do not use powder-actuated concrete fasteners for seismic restraints.
- C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 4-1 (Table 4-1M), "Rectangular Duct Hangers Minimum Size," and Table 4-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches (610 mm) of each elbow and within 48 inches (1200 mm) of each branch intersection.
- D. Hangers Exposed to View: Threaded rod and angle or channel supports.
- E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet (5 m).
- F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.4 CONNECTIONS

- A. Make connections to equipment with flexible connectors complying with Division 23 Section "Air Duct Accessories."
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.5 PAINTING

- A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Division 09 painting Sections.

3.6 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Leakage Tests:
 - 1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual."
 - 2. Test the following systems:
 - a. Supply air.
 - 3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
 - 4. Test for leaks before insulation application.
 - 5. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test entire system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure. Give seven days' advance notice for testing.
- C. Duct System Cleanliness Tests:
 - 1. Visually inspect duct system to ensure that no visible contaminants are present.
 - 2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."
 - a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.
- D. Duct system will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

3.7 DUCT SCHEDULE

- A. Fabricate ducts with galvanized sheet steel.
- B. Intermediate Reinforcement:
 - 1. Galvanized-Steel Ducts: Galvanized steel.
- C. Elbow Configuration:
 - 1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Elbows."
 - a. Velocity 1000 fpm (5 m/s) or Lower:
 - 1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
 - 2) Mitered Type RE 4 without vanes.
 - b. Velocity 1000 to 1500 fpm (5 to 7.6 m/s):
 - 1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
 - 2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
 - 3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible,"

- Figure 2-3, "Vaness and Vane Runners," and Figure 2-4, "Vane Support in Elbows."
- c. Velocity 1500 fpm (7.6 m/s) or Higher:
 - 1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
 - 2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
 - 3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-3, "Vaness and Vane Runners," and Figure 2-4, "Vane Support in Elbows."
 - 2. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-3, "Round Duct Elbows."
 - a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.
 - 1) Velocity 1000 fpm (5 m/s) or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
 - 2) Velocity 1000 to 1500 fpm (5 to 7.6 m/s): 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
 - 3) Velocity 1500 fpm (7.6 m/s) or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
 - b. Round Elbows, 12 Inches (305 mm) and Smaller in Diameter: Stamped or pleated.
 - c. Round Elbows, 14 Inches (356 mm) and Larger in Diameter: Standing seam.
 - D. Branch Configuration:
 - 1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-6, "Branch Connections."
 - a. Rectangular Main to Rectangular Branch: 45-degree entry.
 - b. Rectangular Main to Round Branch: Spin in.
 - 2. Round: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees." Saddle taps are permitted in existing duct.
 - a. Velocity 1000 fpm (5 m/s) or Lower: 90-degree tap.
 - b. Velocity 1000 to 1500 fpm (5 to 7.6 m/s): Conical tap.
 - c. Velocity 1500 fpm (7.6 m/s) or Higher: 45-degree lateral.

END OF SECTION 23 31 13

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SECTION 23 33 00 - AIR DUCT ACCESSORIES**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. Backdraft and pressure relief dampers.
 - 2. Barometric relief dampers.
 - 3. Manual volume dampers – Handle Actuated
 - 4. Manual volume dampers – Remote Actuated
 - 5. Control dampers.
 - 6. Fire dampers.
 - 7. Flange connectors.
 - 8. Turning vanes.
 - 9. Duct-mounted access doors.
 - 10. Flexible connectors.
 - 11. Duct accessory hardware.

1.3 SUBMITTALS

- A. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.
 - 1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:
 - a. Special fittings.
 - b. Manual volume damper installations. Handle, Cable, and Shaft actuated.
 - c. Control damper installations.
 - d. Fire-damper, combination fire- and smoke-damper, including sleeves; and duct-mounted access doors and remote damper operators.
 - e. Wiring Diagrams: For power, signal, and control wiring.
- B. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from Installers of the items involved.
- C. Source quality-control reports.
- D. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.4 QUALITY ASSURANCE

- A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."
- B. Comply with AMCA 500-D testing for damper rating.

1.5 EXTRA MATERIALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
 - 1. Galvanized Coating Designation: G90 (Z275).
 - 2. Exposed-Surface Finish: Mill phosphatized.
- C. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.
- D. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

2.2 BACKDRAFT AND PRESSURE RELIEF DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Greenheck Fan Corporation.
 - 2. Nailor Industries Inc.
 - 3. NCA Manufacturing, Inc.
 - 4. Pottorff, a division of PCI Industries, Inc.
 - 5. Ruskin Company.
- B. Description: Gravity balanced
- C. Maximum Air Velocity: 2000 fpm (10 m/s)
- D. Maximum System Pressure: 5-inch wg (0.25 kPa)
- E. Frame: 0.063-inch- (1.6-mm-) thick extruded aluminum.
- F. Blades: Multiple single-piece blades, maximum 6-inch (150-mm) width, 0.025-inch- (0.6-mm-) thick, roll-formed aluminum with sealed edges.
- G. Blade Action: Parallel.
- H. Blade Seals: Neoprene, mechanically locked.
- I. Blade Axles:
 - 1. Material: Galvanized steel.
 - 2. Diameter: 0.20 inch (5 mm)
- J. Tie Bars and Brackets: Galvanized steel.
- K. Return Spring: Adjustable tension.
- L. Bearings: Steel ball.
- M. Accessories:
 - 1. Adjustment device to permit setting for varying differential static pressure.
 - 2. Counterweights and spring-assist kits for vertical airflow installations.
 - 3. Electric actuators.
 - 4. Chain pulls.
 - 5. Front of rear screens.
 - 6. 90-degree stops.
- N. Sleeve: Minimum 20-gage (1.0-mm) thickness.

2.3 BAROMETRIC RELIEF DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Greenheck Fan Corporation.
 - 2. Nailor Industries Inc.
 - 3. NCA Manufacturing, Inc.

- 4. Pottorff; a division of PCI Industries, Inc.
 - 5. Ruskin Company.
- B. Suitable for horizontal or vertical mounting.
- C. Maximum Air Velocity: 2000 fpm (10 m/s).
- D. Maximum System Pressure: 5-inch wg (0.5 kPa).
- E. Frame: 0.064-inch- (1.6-mm-) thick, galvanized sheet steel, with welded corners and mounting flange.
- F. Blades:
 - 1. Multiple, 0.025-inch- (0.6-mm-) thick, roll-formed aluminum.
 - 2. Maximum Width: 6 inches (150 mm).
 - 3. Action: Parallel.
 - 4. Balance: Gravity.
 - 5. Eccentrically pivoted.
- G. Blade Seals: Neoprene.
- H. Blade Axles: Galvanized steel.
- I. Tie Bars and Brackets:
 - 1. Material: Galvanized steel.
 - 2. Rattle free with 90-degree stop.
- J. Return Spring: Adjustable tension.
- K. Bearings: Stainless steel.
- L. Accessories:
 - 1. Flange on intake.
 - 2. Adjustment device to permit setting for varying differential static pressures.

2.4 MANUAL VOLUME DAMPERS (HANDLE ACTUATED)

- A. Standard, Steel, Manual Volume Dampers:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Air Balance Inc.; a division of Mestek, Inc.
 - b. METALAIRE, Inc.
 - c. Nailor Industries Inc.
 - d. Pottorff; a division of PCI Industries, Inc.
 - e. Ruskin Company.
 - 2. Standard leakage rating.
 - 3. Suitable for horizontal or vertical applications.
 - 4. Frames:
 - a. Hat-shaped, galvanized-steel channels, 0.064-inch (1.62-mm) minimum thickness.
 - b. Mitered and welded corners.
 - c. Flanges for attaching to walls and flangeless frames for installing in ducts.
 - 5. Blades:
 - a. Multiple or single blade.
 - b. Parallel- or opposed-blade design.
 - c. Stiffen damper blades for stability.
 - d. Galvanized-steel, 0.064 inch (1.62 mm) thick.
 - 6. Blade Axles: Galvanized steel.
 - 7. Bearings:
 - a. Stainless-steel sleeve.
 - b. Dampers in ducts with pressure classes of 3-inch wg (750 Pa) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
 - 8. Tie Bars and Brackets: Galvanized steel.
- B. Jackshaft:
 - 1. Size: 1-inch (25-mm) diameter.

2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
 3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.
- C. Damper Hardware
1. Zinc-plated, die-cast core with dial and handle made of 3/32-inch- (2.4-mm-) thick zinc-plated steel, and a 3/4-inch (19-mm) hexagon locking nut.
 2. Include center hole to suit damper operating-rod size.
 3. Include elevated platform for insulated duct mounting.

2.5 MANUAL VOLUME DAMPERS (REMOTE ACTUATED)

- A. Standard, Steel, Manual Volume Dampers:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Air Balance Inc.; a division of Mestek, Inc.
 - b. METALAIR, Inc.
 - c. Nailor Industries Inc.
 - d. Pottorff; a division of PCI Industries, Inc.
 - e. Ruskin Company.
 2. Standard leakage rating.
 3. Suitable for horizontal or vertical applications.
 4. Frames:
 - a. Hat-shaped, galvanized-steel channels, 0.064-inch (1.62-mm) minimum thickness.
 - b. Mitered and welded corners.
 - c. Flanges for attaching to walls and flangeless frames for installing in ducts.
 5. Blades:
 - a. Radial-Twist
 6. Blade Axles: Galvanized steel.
 7. Tie Bars and Brackets: Galvanized steel.
- B. Damper Hardware
1. Provide 60" cable, field cut to terminate at face of service diffuser.
 2. Cable actuated with hexagonal nut driver.

2.6 CONTROL DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Duro Dyne Inc.
 2. Flexmaster U.S.A., Inc.
 3. Greenheck Fan Corporation.
 4. METALAIR, Inc.
 5. Nailor Industries Inc.
 6. NCA Manufacturing, Inc.
 7. Ruskin Company.
- B. Low-leakage rating, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
- C. Frames:
1. Angle shaped.
 2. Galvanized-steel channels, 0.064 inch (1.62 mm) thick.
 3. Mitered and welded corners.
- D. Blades:
1. Multiple blade with maximum blade width of 8 inches (200 mm).
 2. Opposed-blade design.
 3. Galvanized Stainless steel.

4. 0.064 inch (1.62 mm) thick.
5. Blade Edging: Closed-cell neoprene edging.
- E. Blade Axles: 1/2-inch- (13-mm-) diameter; galvanized steel; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings.
 1. Operating Temperature Range: From minus 40 to plus 200 deg F (minus 40 to plus 93 deg C).
- F. Bearings:
 1. Oil-impregnated bronze.
 2. Dampers in ducts with pressure classes of 3-inch wg (750 Pa) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
 3. Thrust bearings at each end of every blade.

2.7 FIRE DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Greenheck Fan Corporation.
 2. METALAIR, Inc.
 3. Nailor Industries Inc.
 4. NCA Manufacturing, Inc.
 5. Pottorff; a division of PCI Industries, Inc.
 6. Prefco; Perfect Air Control, Inc.
 7. Ruskin Company.
- B. Type: Dynamic; rated and labeled according to UL 555 by an NRTL.
- C. Closing rating in ducts up to 5-inch wg static pressure class and minimum 4000-fpm (20-m/s) velocity.
- D. Fire Rating: 1-1/2] hours.
- E. Frame: Curtain type with blades outside airstream; fabricated with roll-formed, 0.034-inch- (0.85-mm-) thick galvanized steel; with mitered and interlocking corners.
- F. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.
 1. Minimum Thickness: 0.052 or 0.138 inch (1.3 or 3.5 mm) thick, as indicated, and of length to suit application.
 2. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.
- G. Mounting Orientation: Vertical or horizontal as indicated.
- H. Blades: Roll-formed, interlocking, 0.034-inch- (0.85-mm-) thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- (0.85-mm-) thick, galvanized-steel blade connectors.
- I. Horizontal Dampers: Include blade lock and stainless-steel closure spring.
- J. Heat-Responsive Device: Replaceable, 165 deg F (74 deg C) rated, fusible links.

2.8 FLANGE CONNECTORS

- A. Description: Roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.
- B. Material: Galvanized steel.
- C. Gage and Shape: Match connecting ductwork.

2.9 TURNING VANES

- A. Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
 1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

- B. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
- C. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-3, "Vanes and Vane Runners," and 2-4, "Vane Support in Elbows."
- D. Vane Construction: Single wall.
- E. Vane Construction: Single wall for ducts up to 48 inches (1200 mm) wide and double wall for larger dimensions.

2.10 DUCT-MOUNTED ACCESS DOORS

- A. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-10, "Duct Access Doors and Panels," and 2-11, "Access Panels - Round Duct."
 - 1. Door:
 - a. Double wall, rectangular.
 - b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
 - c. Vision panel.
 - d. Hinges and Latches: 1-by-1-inch (25-by-25-mm) butt or piano hinge and cam latches.
 - e. Fabricate doors airtight and suitable for duct pressure class.
 - 2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
 - 3. Number of Hinges and Locks:
 - a. Access Doors Less Than 12 Inches (300 mm) Square: No hinges and two sash locks.
 - b. Access Doors up to 18 Inches (460 mm) Square: Two hinges and two sash locks.
 - c. Access Doors up to 24 by 48 Inches (600 by 1200 mm): Three hinges and two compression latches.
 - d. Access Doors Larger Than 24 by 48 Inches (600 by 1200 mm): Four hinges and two compression latches with outside and inside handles.

2.11 FLEXIBLE CONNECTORS

- A. Materials: Flame-retardant or noncombustible fabrics.
- B. Coatings and Adhesives: Comply with UL 181, Class 1.
- C. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.
 - 1. Minimum Weight: 26 oz./sq. yd. (880 g/sq. m).
 - 2. Tensile Strength: 480 lbf/inch (84 N/mm) in the warp and 360 lbf/inch (63 N/mm) in the filling.
 - 3. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).

2.12 DUCT ACCESSORY HARDWARE

- A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.
- B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.
- B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.
- C. Install backdraft dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.
- D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.
 - 1. Coordinate subparagraphs below with Division 23 Section "Metal Ducts." Install steel volume dampers in steel ducts.
 - 2. Install aluminum volume dampers in aluminum ducts.
- E. Set dampers to fully open position before testing, adjusting, and balancing.
- F. Install test holes at fan inlets and outlets and elsewhere as indicated.
- G. Install fire dampers according to UL listing.
- H. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
 - 1. On both sides of duct coils.
 - 2. Downstream from manual volume dampers, control dampers, and equipment.
 - 3. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
 - 4. At each change in direction and at maximum 50-foot (15-m) spacing.
 - 5. Upstream of turning vanes.
 - 6. Elsewhere as indicated.
- I. Install access doors with swing against duct static pressure.
- J. Access Door Sizes:
 - 1. One-Hand or Inspection Access: 8 by 5 inches (200 by 125 mm).
 - 2. Two-Hand Access: 12 by 6 inches (300 by 150 mm).
 - 3. Head and Hand Access: 18 by 10 inches (460 by 250 mm).
 - 4. Head and Shoulders Access: 21 by 14 inches (530 by 355 mm).
 - 5. Body Access: 25 by 14 inches (635 by 355 mm).
 - 6. Body plus Ladder Access: 25 by 17 inches (635 by 430 mm).
- K. Label access doors according to Division 23 Section "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.
- L. Install flexible connectors to connect ducts to equipment.
- M. For fans developing static pressures of 5-inch wg (1250 Pa) and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.
- N. Install duct test holes where required for testing and balancing purposes.
- O. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch (6-mm) movement during start and stop of fans.

3.2 FIELD QUALITY CONTROL

- A. Tests and Inspections:
 - 1. Operate dampers to verify full range of movement.

2. Inspect locations of access doors and verify that purpose of access door can be performed.
3. Operate fire, dampers to verify full range of movement and verify that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation.

END OF SECTION 23 33 00

SECTION 23 34 23 - HVAC POWER VENTILATORS**PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. In-line centrifugal fans.
 - 2. Sidewall propeller fans.

1.3 PERFORMANCE REQUIREMENTS

- A. Operating Limits: Classify according to AMCA 99.

1.4 SUBMITTALS

- A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:
 - 1. Certified fan performance curves with system operating conditions indicated.
 - 2. Certified fan sound-power ratings.
 - 3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
 - 4. Material thickness and finishes, including color charts.
 - 5. Dampers, including housings, linkages, and operators.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 1. Wiring Diagrams: Power, signal, and control wiring.
 - 2. Design Calculations: Calculate requirements for selecting vibration isolators.

1.5 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.
- C. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.
- D. UL Standard: Power ventilators shall comply with UL 705.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver fans as factory-assembled unit, to the extent allowable by shipping limitations, with protective crating and covering.
- B. Disassemble and reassemble units, as required for moving to final location, according to manufacturer's written instructions.
- C. Lift and support units with manufacturer's designated lifting or supporting points.

1.7 COORDINATION

- A. Coordinate size and location of structural-steel support members.

1.8 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Belts: Two set(s) for each belt-driven unit.

PART 2 - PRODUCTS

2.1 IN-LINE CENTRIFUGAL FANS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Twin City
 - 2. Greenheck.
 - 3. Loren Cook Company.
- B. Description: In-line, direct-driven centrifugal fans consisting of housing, wheel, outlet guide vanes, fan shaft, bearings, motor and disconnect switch, drive assembly, mounting brackets, and accessories.
- C. Housing: Split, spun aluminum with aluminum straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.
- D. Direct-Driven Units: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing.
- E. Belt-Driven Units: Motor mounted on adjustable base, with adjustable sheaves, enclosure around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.
- F. Fan Wheels: Aluminum, airfoil blades welded to aluminum hub.
- G. Accessories:
 - 1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
 - 2. Volume-Control Damper: Manually operated with quadrant lock, located in fan outlet.
 - 3. Companion Flanges: For inlet and outlet duct connections.
 - 4. Fan Guards: 1/2- by 1-inch (13- by 25-mm) mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.
 - 5. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.

2.2 SIDEWALL PROPELLER FANS

- A. Housing: Galvanized-steel sheet with flanged edges and integral orifice ring, with baked-enamel finish coat applied after assembly.
- B. Fan Wheels: Formed-steel blades riveted to heavy-gauge steel spider bolted to cast-iron hub.
- C. Fan Wheel: Replaceable, cast-aluminum, airfoil blades fastened to cast-aluminum hub; factory set pitch angle of blades.
- D. Fan Drive: Direct-drive motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing.
- E. Fan Drive:
 - 1. Belt drive.
 - 2. Resiliently mounted to housing.
 - 3. Statically and dynamically balanced.
 - 4. Selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
 - 5. Extend grease fitting to accessible location outside of unit.

6. Service Factor Based on Fan Motor Size: 1.4.
 7. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
 8. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
 - a. Ball-Bearing Rating Life: ABMA 9, L(10) of 100,000 hours.
 9. Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
 10. Motor Pulleys: Adjustable pitch for use with motors through 5hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
 11. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
 12. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.
- F. Accessories:
1. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.
 2. Motorized Dampers: Parallel-blade dampers with electric actuator wired to close when fan stops.
 3. Motor-Side Back Guard: Galvanized steel, complying with OSHA specifications, removable for maintenance.
 4. Wall Sleeve: Galvanized steel to match fan and accessory size.
 5. Weathershield Hood: Galvanized steel to match fan and accessory size.
 6. Weathershield Front Guard: Galvanized steel with expanded metal screen.

2.3 MOTORS

- A. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
- B. Enclosure Type: Totally enclosed, fan cooled.

2.4 SOURCE QUALITY CONTROL

- A. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.
- B. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install power ventilators level and plumb.
- B. Support units using elastomeric mounts having a static deflection of 1 inch (25 mm)
- C. Install units with clearances for service and maintenance.
- D. Label units according to requirements specified in Division 23 Section "Identification for HVAC Piping and Equipment." .
- E. All Electrical power wiring, raceway, panels, and devices shall comply with Div 26 requirements.

3.2 CONNECTIONS

- A. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 23 Section "Air Duct Accessories."
- B. Install ducts adjacent to power ventilators to allow service and maintenance.

- C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
 - 1. Verify that shipping, blocking, and bracing are removed.
 - 2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
 - 3. Verify that cleaning and adjusting are complete.
 - 4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
 - 5. Adjust belt tension.
 - 6. Adjust damper linkages for proper damper operation.
 - 7. Verify lubrication for bearings and other moving parts.
 - 8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
 - 9. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
 - 10. Shut unit down and reconnect automatic temperature-control operators.
 - 11. Remove and replace malfunctioning units and retest as specified above.
- B. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.4 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Adjust belt tension.
- C. Refer to Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.
- D. Replace fan and motor pulleys as required to achieve design airflow.
- E. Lubricate bearings.

END OF SECTION 23 34 23

SECTION 23 37 13 - DIFFUSERS, REGISTERS, AND GRILLES**PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Rectangular and square ceiling diffusers.
 - 2. Louver face diffusers.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated, include the following:
 - 1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
 - 2. Diffuser, Register, and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.
- B. Samples: For each exposed product and for each color and texture specified.

PART 2 - PRODUCTS**2.1 CEILING DIFFUSERS**

- A. See units specified on drawings
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. METALAIRE, Inc.
 - b. Nailor Industries Inc.
 - c. Titus.
- B. All diffusers, registers and grilles shall be of aluminum construction.

2.2 SOURCE QUALITY CONTROL

- A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION**3.1 INSTALLATION**

- A. Install diffusers, registers, and grilles level and plumb.
- B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in

- lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.
- C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.2 ADJUSTING

- A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 23 37 13

SECTION 23 55 23 - GAS-FIRED RADIANT HEATERS**PART 1 - GENERAL****1.1 SUMMARY**

- A. This Section includes gas-fired, tubular infrared radiant heaters and associated GAS PIPING.

1.2 SUBMITTALS

- A. Product Data: For each type of gas-fired radiant heater indicated. Include rated capacities, operating characteristics, and accessories.
- B. Product Data: For type of pipe and fittings.
- C. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 1. Wiring Diagrams: Power, signal, and control wiring.
- D. Field quality-control test reports.
- E. Operation and maintenance data.

1.3 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.4 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of gas-fired radiant heater that fails in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS**2.1 TUBULAR INFRARED HEATERS**

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- C. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 - 1. Gas-Fired Products Inc.; Space-Ray Div.
 - 2. Reznor/Thomas & Betts Corporation.
 - 3. Schwank Inc.
- D. Description: Factory assembled, piped, and wired, and complying with ANSI Z83.20/CSA 2.34.
- E. Fuel Type: Design burner for natural gas having characteristics same as those of gas available at Project site.

- F. Combustion Tubing: 4-inch- (100-mm-) diameter steel with high-emissivity, high-temperature, corrosion-resistant external finish.
- G. Tubing Connections: Stainless-steel couplings or flared joints with stainless-steel draw bolts.
- H. Reflector: Polished aluminum, 97 percent minimum reflectivity, with end caps. Shape to control radiation from tubing for uniform intensity at floor level with 100 percent cutoff above centerline of tubing. Provide for rotating reflector or heater around a horizontal axis for minimum 30-degree (0.52-radian) tilt from vertical.
 - 1. Reflector Extension Shields: Same material as reflectors, arranged for fixed connection to lower reflector lip and rigid support to provide 100 percent cutoff of direct radiation from tubing at angles greater than 30 degrees (0.52 radians) from vertical.
 - 2. Include hanger kit.
- I. Burner Safety Controls:
 - 1. Gas Control Valve: Single-stage, regulated redundant 24-V ac gas valve containing pilot solenoid valve, electric gas valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body.
 - 2. Blocked Vent Safety: Differential pressure switch in burner safety circuit to stop burner operation with high discharge or suction pressure.
 - 3. Control Panel Interlock: Stops burner if panel is open.
 - 4. Indicator Lights: Burner-on indicator light.
- J. Burner and Emitter Type: Gravity-vented power burner, with the following features:
 - 1. Emitter Tube: 4-inch- (100-mm-) diameter, hot-rolled-steel tubing with sight glass for burner and pilot flame observation.
 - 2. Venting: Connector at exit end of emitter tubing for vent-pipe connection
 - a. Vent Terminal: Vertical and/or Horizontal. (See plans)
 - 3. Burner/Ignition: Power gas burner with electronic spark and electronic flame safety.
 - 4. Burner/Ignition: Stainless-steel burner cup and head with balanced-rotor draft fan and spark ignition with electronic flame supervision.
 - 5. Combustion-Air Connection: Duct connection for combustion air to be drawn directly from outdoors by burner fan.
- K. Capacities and Characteristics:
 - 1. Gas Input: See Mech. Schedules
 - 2. Gas Output: See Mech. Schedules
 - 3. Fuel Supply Connection: See Mech. Schedules
 - a. Volts: 120 V.
 - b. Phase: Single.
 - c. Hertz: 60.

2.2 CONTROLS

- A. Thermostat: 2-stage, wall-mounting type with 50 to 90 deg F (10 to 32 deg C) operating range and fan on switch.
 - 1. Control Transformer: Integrally mounted.

2.3 PIPES, TUBES, AND FITTINGS

- A. Steel Pipe: ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.
 - 1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
 - 2. Wrought-Steel Welding Fittings: ASTM A 234/A 234M for butt welding and socket welding.
 - 3. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
 - 4. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.

- a. Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.

2.4 MANUAL GAS SHUTOFF VALVES

- A. General Requirements for Metallic Valves, NPS 2 (DN 50) and Smaller: Comply with ASME B16.33.
 1. CWP Rating: 125 psig (862 kPa).
 2. Threaded Ends: Comply with ASME B1.20.1.
 3. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
 4. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
 5. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch (25 mm) and smaller.
 6. Service Mark: Valves 1-1/4 inches (32 mm) to NPS 2 (DN 50) shall have initials "WOG" permanently marked on valve body.
- B. One-Piece, Bronze Ball Valve with Bronze Trim: MSS SP-110.
 1. 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:
 - a. BrassCraft Manufacturing Company; a Masco company.
 - b. Conbraco Industries, Inc.; Apollo Div.
 - c. Lyall, R. W. & Company, Inc.
 - d. McDonald, A. Y. Mfg. Co.
 - e. Perfection Corporation; a subsidiary of American Meter Company.
 2. Body: Bronze, complying with ASTM B 584.
 3. Ball: Chrome-plated brass.
 4. Stem: Bronze; blowout proof.
 5. Seats: Reinforced TFE; blowout proof.
 6. Packing: Separate packnut with adjustable-stem packing threaded ends.
 7. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
 8. CWP Rating: 600 psig (4140 kPa).
 9. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
 10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install and connect gas-fired radiant heaters and associated fuel and vent features and systems according to NFPA 54, applicable local codes and regulations, and manufacturer's written installation instructions.
- B. Suspended Units: Suspend from substrate using chain hanger kits and building attachments.
- C. Maintain manufacturers' recommended clearances to combustibles.
- D. Install piping adjacent to gas-fired radiant heaters to allow service and maintenance.
- E. Gas Piping: Connect gas piping to gas train inlet; provide union with enough clearance for burner removal and service.
- F. Vent Connections: Comply with manufacturers written instructions.
- G. Electrical Connections: Comply with applicable requirements in Division 26 Sections.

1. Install electrical devices furnished with heaters but not specified to be factory mounted.
- H. Adjust initial temperature set points.
- I. Adjust burner and other unit components for optimum heating performance and efficiency.

3.2 INDOOR PIPING SCHEDULE

- A. Aboveground, distribution piping shall be **[one of]** the following:
 1. Steel pipe with malleable-iron fittings and threaded joints.
 2. Steel pipe with wrought-steel fittings and welded joints.

3.3 PAINTING AND IDENTIFICATION

- A. Prep, primer and paint all interior and exterior gas piping yellow, provide labels identifying natural gas piping and pressure. Lettering shall stenciled in black paint on piping every 15 ft. minimum and on either side of walls.

3.4 FIELD QUALITY CONTROL

- A. Tests and Inspections: Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

END OF SECTION 23 55 23

SECTION 23 72 23 – PACKAGED INDOOR FIXED PLATE ENERGY RECOVERY UNITS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Fixed-plate, total heat exchangers in packaged, indoor, energy-recovery units.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: For packaged, indoor, fixed-plate, energy-recovery units.
 - 1. Include plans, elevations, sections, details, and mounting 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.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans, elevations, and other details, drawn to scale and coordinated with each other, using input from installers of the items involved.
- B. Seismic Qualification Data: Certificates, for packaged, indoor, fixed-plate, energy-recovery units, accessories, and components, from manufacturer.
- C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.5 COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided.

1.6 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of packaged, indoor, fixed-plate, energy-recovery units that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period for Packaged Energy-Recovery Units: 10 years.

PART 2 - PRODUCTS**2.1 PERFORMANCE REQUIREMENTS**

- A. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.
- B. ASHRAE Compliance:
 - 1. Applicable requirements in ASHRAE 62.1.
 - 2. Capacity ratings for fixed-plate energy-recovery units shall comply with ASHRAE 84.
- C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1.
- D. UL Compliance:
 - 1. Packaged heat-recovery ventilators shall comply with requirements in UL 1812 or UL 1815.
 - 2. Electric coils shall comply with requirements in UL 1995.
- E. Comply with ASTM E84.

2.2 PACKAGED, INDOOR, FIXED-PLATE TOTAL ENERGY RECOVERY UNITS

- A. Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- B. Housing: Manufacturer's standard construction with corrosion-protection coating and exterior finish, removable panels with neoprene gaskets for inspection and access to internal parts, minimum 1- (25-)inch- (mm-) thick R-8 thermal insulation, knockouts for electrical connections, exterior drain connection, and lifting lugs.
- C. Fixed-Plate Total Heat Exchanger:
 - 1. Casing: Galvanized steel.
 - 2. Plates: Evenly spaced and sealed and arranged for counter or cross-flow.
 - a. Plate Material: Chemically treated paper or polymer membrane with selective hydroscopicity and moisture permeability, and gas barrier properties.
- D. Supply and Exhaust Fans: Forward-curved centrifugal fan with restrained spring isolators of 1-Motor and Drive: Direct driven
 - 1. Default motor characteristics are specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
 - 2. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
 - 3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
- E. Filters:
 - 1. Particulate air filtration is specified in Section 234100 "Particulate Air Filtration."
- F. Filters:
 - 1. Description: Pleated factory-fabricated, self-supported, disposable air filters with holding frames.
 - 2. UL Compliance: Comply with UL 900.
 - 3. Media: Interlaced glass fibers sprayed with nonflammable adhesive and antimicrobial agent.
 - 4. Filter Mounting Frames: Arranged with access doors or panels on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
- G. Wiring: Fabricate units with space within housing for electrical conduits. Wire motors and controls, so only external connections are required during installation.
 - 1. Indoor Enclosure: NEMA 250, Type 12 enclosure contains relays, starters, and terminal strip.
 - 2. Include fused disconnect switches.

2.3 SOURCE QUALITY CONTROL

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- B. AHRI Compliance: Capacity ratings for air-to-air energy-recovery equipment certified as complying with AHRI 1060 (AHRI 1061).
- C. Fan Performance Rating: Comply with AMCA 211 and label fans with AMCA-certified rating seal. Factory test fan performance for airflow, pressure, power, air density, rotation speed, and efficiency according to AMCA 210/ASHRAE 51.
- D. Fan Sound Ratings: Comply with AMCA 301 or AHRI 260 (IP). Air-handling unit fan sound ratings shall comply with AMCA 301 or AHRI 260 (IP).
- E. UL Compliance:
 - 1. Packaged fixed plate energy recovery units shall comply with requirements in UL 1812; or UL 1815.
 - 2. Electric Coils: Comply with UL 1995.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Examine casing insulation materials and filter media before packaged, indoor, fixed-plate, energy-recovery unit installation. Replace with new insulation materials and filter media that are wet, moisture damaged, or mold damaged.
- B. Install packaged, indoor, fixed-plate, energy-recovery units, so supply and exhaust airstreams flow in opposite directions.
 - 1. Install access doors in both supply and exhaust ducts, both upstream and downstream, for access to interior components.
 - 2. Install removable panels or access doors between supply and exhaust ducts on building side for bypass during startup.
 - 3. Access doors and panels are specified in Section 233300 "Air Duct Accessories."
- C. Suspended Units: Suspend units from structural-steel support frame, using threaded steel rods and spring hangers. Comply with requirements for vibration-isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
- D. Install units with clearances for service and maintenance.
- E. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing with new, clean filters.

3.2 DUCTWORK CONNECTIONS

- A. Comply with requirements for ductwork according to Section 233113 "Metal Ducts."
- B. Connect duct to units with flexible connections. Comply with requirements in Section 233300 "Air Duct Accessories."

3.3 PIPING CONNECTIONS

- A. Where installing piping adjacent to unit, allow for service and maintenance.
- B. Connect piping to units mounted on vibration isolators with flexible connectors.
- C. Condensate Drain Piping: See Section 232113 "Hydronic Piping" for pipe type. Pipe drains from drain pans to nearest floor drain, same size as condensate drain connection.
 - 1. Construct deep trap at connection to drain pan, and install cleanouts at changes in direction.

3.4 ELECTRICAL CONNECTIONS

- A. Install electrical devices furnished with units but not factory mounted.
- B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- D. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.
- E. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch (13 mm) high.

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- C. Perform tests and inspections with the assistance of a factory-authorized service representative.
- D. Tests and Inspections:
 - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- E. Packaged, indoor, fixed-plate, energy-recovery units will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.

3.6 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain air-to-air energy-recovery units.

END OF SECTION 23 72 23

SECTION 23 81 25 - SPLIT-SYSTEM HEAT PUMPS**PART 1 - GENERAL****1.1 SUMMARY**

- A. This Section includes split-system air-conditioning and heat pump units consisting of separate evaporator-fan and compressor-condenser components. Units are designed for exposed or concealed mounting, and may be connected to ducts.

1.2 SUBMITTALS

- A. Product Data: For each unit indicated. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.
- B. Operation and maintenance data.

1.3 DEFINITIONS

- A. Heat-Pump System Operation: System capable of operation with all zones in either heating or cooling, but not with simultaneous heating and cooling zones that transfer heat between zones.
- B. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.
- C. Plenum: A space forming part of the air distribution system to which one or more air ducts are connected. An air duct is a passageway, other than a plenum, for transporting air to or from heating, ventilating, or air-conditioning equipment.
- D. High-Probability System. A high-probability system is any refrigeration system in which the basic design or the location of components is such that a leakage of refrigerant from a failed connection, seal, or component will enter the occupied space. Typical high-probability systems are (a) direct systems or (b) indirect open spray systems in which the refrigerant is capable of producing pressure greater than the secondary coolant.
- E. Air circulation: mechanically inducing airflow within a space or spaces connected by air ducts.
- F. Refrigerant detection system: a system, or portion of a combination system, that utilizes one or more devices to detect the presence of a specified refrigerant at a specified concentration and initiates one or more mitigation actions required by this standard.
- G. Refrigerant detector: a device that is capable of sensing the presence of refrigerant vapor.
- H. Mitigation actions: actions taken by equipment that are initiated by detection of leaked refrigerant by the refrigerant detector.
- I. Connected spaces: two or more spaces connected by natural ventilation, a ducted air distribution system, or mechanical ventilation.
- J. Effective dispersal volume: the volume of a space or connected spaces in which leaked refrigerant will disperse.
- K. Effective dispersal volume charge (EDVC): the maximum refrigerant charge permitted for an effective dispersal volume.
- L. Releasable refrigerant charge (mrel): a portion of the system refrigerant charge that can be released into a space as a result of a single point of failure.
- M. Mechanical ventilation: the ventilation provided for refrigerant safety mitigation complying with ASHRAE 15-2022 section 7.6.4 by equipment other than the refrigerant equipment providing air circulation, but may be initiated by refrigerant equipment per ASHRAE 15-2022 section 7.6.2.5-c.

- N. Lower flammability limit (LFL): the minimum concentration of a substance, a refrigerant in ASHRAE 34-2022, that is capable of propagating a flame through a homogeneous mixture of the substance and air under specified test conditions.
- O. Refrigerant concentration limit (RCL): the refrigerant concentration limit, in air, determined in accordance with ASHRAE 34-2022 and intended to reduce the risks of acute toxicity, asphyxiation, and flammability hazards in normally occupied, enclosed spaces.

1.4 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Energy-Efficiency Ratio: Equal to or greater than prescribed by ASHRAE 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings."
- C. Coefficient of Performance: Equal to or greater than prescribed by ASHRAE 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings."
- D. Units shall be designed to operate with HCFC-free refrigerants.

1.5 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace split-system air-conditioning units that fail in materials and workmanship within five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Mitsubishi.
 - 2. Carrier
 - 3. Trane.
 - 4. Johnson/York

2.2 EVAPORATOR-FAN UNIT

- A. Description: Factory-assembled complete unit with components, piping, wiring, and controls required for mating to ductwork, piping, power, and controls field connections.
- B. Cabinet:
 - 1. Material: Galvanized or painted steel.
 - 2. Insulation: Manufacturer's standard internal insulation, complying with ASHRAE 62.1, to provide thermal resistance and prevent condensation.
 - 3. Duct Connections: Extended collar or flange, or designated exterior cabinet surface, designed for attaching field-installed ductwork.
 - 4. Mounting: Manufacturer-designed provisions for field installation.
 - 5. Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.
- C. DX Coil Assembly:
 - 1. Coil Casing: Aluminum, galvanized, or stainless steel.
 - 2. Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.
 - 3. Coil Tubes: Copper, of diameter and thickness required by performance.

4. Expansion Valve: Electronic modulating type with linear or proportional characteristics.
5. Unit Internal Tubing: Copper tubing with brazed joints.
6. Unit Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
7. Field Piping Connections: Manufacturer's standard.
8. Factory Charge: Dehydrated air or nitrogen.
9. Testing: Factory pressure tested and verified to be without leaks.
- D. Drain Assembly:
 1. Pan: Non-ferrous material, with bottom sloped to low point drain connection.
 2. Condensate Removal: Unit-mounted pump or other integral lifting mechanism, capable of lifting drain water to an elevation above top of cabinet.
 3. Field Piping Connection: Non-ferrous material.
- E. Fan and Motor Assembly:
 1. Fan(s):
 - a. Direct-drive arrangement.
 - b. Single or multiple fans connected to a common motor shaft and driven by a single motor.
 - c. Materials: Non-ferrous components or ferrous components with corrosion resistant finish.
 - d. Statically and dynamically balanced.
 2. Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
 3. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
 4. Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.
 5. Vibration Control: Integral isolation to dampen vibration transmission.
- F. Filter Assembly:
 1. Access: Bottom, side, or rear to accommodate field installation without removing ductwork and to accommodate filter replacement without need for tools.
 2. Efficiency: **ASHRAE 52.2, MERV 11.**
 3. "Media" Subparagraph below describes two filter types: "replaceable" and "washable." Replaceable filters allow for higher filter efficiency. Washable filters have lower filter efficiency. Requirements may not be available on some products from some manufacturers. Consult manufacturers for availability.
- G. Unit Accessories:
 1. Remote Room Temperature Sensor Kit: Wall-mounted, hardwired room temperature sensor kit for use in rooms that do not have room temperature measurement.
 2. Auxiliary electric heat with share single point power connection. Accessory must be listed for operation with unit and shall be capable of shutdown on signal from refrigerant mitigation/dissipation controller.
- H. Unit Controls:
 1. Enclosure: Metal, suitable for indoor locations.
 2. Factory-Installed Controller: Configurable digital control with refrigerant mitigation controls.
 3. Factory-Installed Sensors:
 - a. Unit inlet air temperature.
 - b. Coil entering refrigerant temperature.
 - c. Coil leaving refrigerant temperature.
 4. Field-Installed, Factory Provided Sensors:
 - a. Refrigerant leak detection sensor located per unit orientation per manufacturer instructions in compliance with UL listing.
 5. Features and Functions:
 - a. Self-diagnostics.
 - b. Time delay, auto-restart.
 - c. External static pressure control.
 - d. Auto operation mode.

- e. Manual operation mode.
 - f. Drain assembly high water level safety shutdown.
 - g. Circulation for refrigerant dissipation, compressor lockout, and auxiliary heat lockout.
 - h. Thermostat alarm for refrigerant detection.
 - i. Refrigerant dissipation test function.
- 6. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
- 7. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
- I. Unit Electrical:
 - 1. Enclosure: Metal, similar to enclosure, and suitable for indoor locations.
 - 2. Field Connection: Single point connection to power unit, integral controls, and auxiliary heat.
 - 3. Disconnecting Means: Factory-mounted circuit breaker or switch.
 - 4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
 - 5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
 - 6. Raceways: Enclose line voltage wiring in metal raceways.

2.3 AIR-COOLED, HEAT PUMP UNIT

- A. General:
 - 1. Factory assembled, single piece, air-cooled outdoor unit. Contained within the unit enclosure is all the factory wiring, piping, controls, and the compressor.
- B. Unit Cabinet:
 - 1. Unit cabinet is constructed of galvanized steel, bonderized and coated with a baked-enamel finish on the inside and outside.
 - 2. Unit access panels is removable with minimal screws and provides full access to the compressor, fan, and control components.
 - 3. The outdoor compartment is isolated and has an acoustic lining to assure quiet operation.
- C. Fans:
 - 1. Outdoor fans are the direct drive propeller type, and discharges air horizontally. Fans draw air through the outdoor coil.
 - 2. Outdoor fan motors are totally enclosed, single phase motors with class E insulation and permanently lubricated ball bearings. Motor shall be protected by internal thermal overload protection.
 - 3. The shaft has inherent corrosion resistance.
 - 4. Fan blades are non-metallic and statically and dynamically balanced.
 - 5. Outdoor fan openings are equipped with a PVC metal/mesh coated protection grille over the fan.
- D. Compressor:
 - 1. Compressor is the fully hermetic rotary type.
 - 2. Compressor is equipped with an oil system, operating oil charge, and a motor.
 - 3. Motor is NEMA rated class E, suitable for operation in a refrigerant atmosphere.
 - 4. Compressor assembly is installed on rubber vibration isolators.
- E. Outdoor Coil:
 - 1. The coil is constructed of aluminum hydrophilic pre-coated fins mechanically bonded to seamless copper tubes, which are cleaned, dehydrated, and sealed.
- F. Refrigeration Components:
 - 1. Refrigerant circuit components include a brass external liquid line service valve with service gage port connections, a suction line service valve with a service gage connection port, service gage port connections on compressor suction and discharge lines with Schrader type fittings with brass caps, accumulator, reversing valve. All service

ports must meet ASHRAE 15-2022 and be provided with labels indicated flammable refrigerant is used, as specified by the product listing.

- G. Controls and Safeties:
 - 1. Operating controls and safeties are factory selected, assembled, and tested. The minimum control functions include the following:
 - a. Controls:
 - 1) A time delay control sequence is provided standard through the fan coil board
 - 2) Automatic outdoor fan motor protection.
 - b. Safeties:
 - 1) System diagnostics
 - 2) Compressor motor current and temperature overload protection
 - 3) Outdoor fan failure protection.
- H. Electrical Requirements:
 - 1. Unit operates on single-phase, 60 Hz power at 208/230V.
 - 2. Unit electrical power has a single point connection.
 - 3. Unit Control voltage to the indoor fan coil is 0-15V DC.
 - 4. All power and control wiring must be installed per NEC and all local electrical codes.
 - 5. The unit has high and low voltage terminal block connections.

2.4 ELECTRIC RESISTANCE COILS

- A. Testing Agency Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Coil Assembly: Comply with UL 1995.
- C. Heating Elements: Coiled resistance wire of 80 percent nickel and 20 percent chromium; surrounded by compacted magnesium-oxide powder in tubular-steel sheath; with spiral-wound, copper-plated, steel fins continuously brazed to sheath.
- D. High-Temperature Coil Protection: Disk-type, automatically reset, thermal-cutout, safety device; serviceable through terminal box without removing heater from duct or casing.
 - 1. Secondary Protection: Load-carrying, manually reset or manually replaceable, thermal cutouts; factory wired in series with each heater stage.
 - 2. Airflow proving switch.

2.5 ACCESSORIES

- A. Thermostat: Low voltage with subbase to control heat pump operations.
 - 1. Thermostat shall be BACNet Compatible.
 - 2. Connect to BACNet Controller in Mechanical Room
- B. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.
- C. Additional Monitoring:
 - 1. Monitor constant and variable motor loads.
 - 2. Monitor variable frequency drive operation.
 - 3. Monitor economizer cycle.
 - 4. Monitor cooling load.
 - 5. Monitor air distribution static pressure and ventilation air volumes.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.
- B. Install ground-mounted, compressor-condenser components on 4-inch- (100-mm-) thick, reinforced concrete base; 4 inches (100 mm) larger on each side than unit. Concrete, reinforcement, and formwork are specified in Specification Section "Cast-in-Place Concrete." Coordinate anchor installation with concrete base.
- C. Install ground-mounted, compressor-condenser components on polyethylene mounting base.
- D. Install compressor-condenser components on restrained, spring isolators with a minimum static deflection of 1 inch (25 mm).
- E. All Electrical power wiring, raceway, panels, and devices shall comply with Div 26 requirements.

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 water coil with shutoff-duty valve and union or flange on the supply connection and with throttling-duty valve and union or flange on the return connection.
- C. Connect supply and return condenser connections with shutoff-duty valve and union or flange on the supply connection and with throttling-duty valve and union or flange on the return connection.
- 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.
- 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 23 81 25

SECTION 23 81 26 – DUCTLESS MINI SPLIT SYSTEMS**PART 1 - GENERAL****1.1 SUMMARY**

- A. This Section includes split-system air-conditioning and heat pump units consisting of separate evaporator-fan and compressor-condenser components. Units are designed for exposed or concealed mounting, and may be connected to ducts.

1.2 SUBMITTALS

- A. Product Data: For each unit indicated. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.
- B. Operation and maintenance data.

1.3 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Energy-Efficiency Ratio: Equal to or greater than prescribed by ASHRAE 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings."
- C. Coefficient of Performance: Equal to or greater than prescribed by ASHRAE 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings."
- D. Units shall be designed to operate with HCFC-free refrigerants.

1.4 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace split-system air-conditioning units, including all parts and labor that fail in materials and workmanship within two years from date of Substantial Completion.
 - 1. Compressor within five years from date of Substantial Completion.

PART 2 - PRODUCTS**2.1 MANUFACTURERS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Carrier Air Conditioning; Div. of Carrier Corp.
 - 2. Mitsubishi Electric Sales Canada, Inc.
 - 3. Trane Co. (The); Unitary Products Group.
 - 4. York International Corp
 - 5. Fujitsu.
 - 6. LG

2.2 EVAPORATOR-FAN UNIT

- A. Concealed Unit Chassis: Galvanized steel with flanged edges, removable panels for servicing, and insulation on back of panel.
 - 1. Insulation: Faced, glass-fiber duct liner.
 - 2. Drain Pans: Galvanized steel, with connection for drain; insulated.

- B. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with thermal-expansion valve.
- C. Evaporator Fan: Forward-curved, double-width wheel of galvanized steel; directly connected to motor.
- D. Fan Motor: Multispeed.
- E. Filters: Permanent, cleanable.

2.3 AIR-COOLED, COMPRESSOR-CONDENSER UNIT

- A. Casing steel, finished with baked enamel, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
- B. Compressor: Hermetically sealed scroll type with crankcase heater and mounted on vibration isolation. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
 - 1. Refrigerant Charge: R-410A.
- C. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with liquid subcooler.
- D. Heat Pump Components: Reversing valve and low-temperature air cut-off thermostat.
- E. Fan: Aluminum-propeller type, directly connected to motor.
- F. Motor: Permanently lubricated, with integral thermal-overload protection.
- G. Low Ambient Kit: Permits operation down to 20 deg F.
- H. Mounting Base: Polyethylene.

2.4 ACCESSORIES

- A. Thermostat: Infrared functioning to remotely control compressor and evaporator fan, with the following features:
 - 1. Compressor time delay.
 - 2. 24-hour time control of system stop and start.
 - 3. Night set Up/ Setback
 - 4. Liquid-crystal display indicating temperature, set-point temperature, time setting, operating mode, and fan speed.
 - 5. Fan-speed selection including auto setting.
 - 6. Thermostat shall be BACNet Compatible.
 - 7. Connect to BACNet Controller in Mechanical Room
- B. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.
- C. Automatic Reset Kit.
- D. Additional Monitoring:
 - 1. Monitor constant and variable motor loads.
 - 2. Monitor variable frequency drive operation.
 - 3. Monitor economizer cycle.
 - 4. Monitor cooling load.
 - 5. Monitor air distribution static pressure and ventilation air volumes.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.
- B. Install ground-mounted, compressor-condenser components on 4-inch- (100-mm-) thick, reinforced concrete base; 4 inches (100 mm) larger on each side than unit. Concrete,

reinforcement, and formwork are specified in Division 03 Section "Cast-in-Place Concrete." Coordinate anchor installation with concrete base.

- C. Install ground-mounted, compressor-condenser components on polyethylene mounting base.
- D. Install roof-mounted, compressor-condenser components on treated 4x4 timbers, with isolator pads.
- E. All Electrical power wiring, raceway, panels, and devices shall comply with Div 26 requirements.

3.2 CONNECTIONS

- A. Connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.
- B. 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.
- 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 23 81 26

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SECTION 23 84 16 - INDOOR, MECHANICAL DEHUMIDIFICATION UNITS**PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

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

1.2 SUMMARY

- A. Section includes packaged, factory-assembled and -tested, refrigerant-type, indoor, mechanical dehumidification units designed for indoor installation.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of indoor, mechanical dehumidification unit.
 - 1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings: For each indoor, mechanical dehumidification unit.
 - 1. Include plans, elevations, sections and mounting 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. Detail fabrication and assembly of dehumidification units.
 - 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.
 - 5. Include diagrams for power, signal, and control wiring.
- C. Delegated-Design Submittal: For indoor, mechanical dehumidification units.
 - 1. 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.
 - 2. Include design calculations for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.

1.4 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Data: Certificates for indoor, mechanical dehumidification units, accessories, and components, from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- B. Product Test Reports: For each indoor, mechanical dehumidification unit, for tests performed by a qualified testing agency.
- C. Field quality-control reports.

- D. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For dehumidification units to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Filters: One set of each type of filter specified.
 - 2. Fan Belts: One set for each belt-drive fan.

1.7 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An NRTL.

1.8 COORDINATION

- A. Coordinate installation of equipment supports.

1.9 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of indoor, mechanical dehumidification units that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period for Compressors: Manufacturer's standard, but not less than **five** years from date of Substantial Completion.
 - 2. Warranty Period for Refrigerant Coils: Manufacturer's standard, but not less than **five** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 INDOOR, MECHANICAL DEHUMIDIFICATION UNIT MANUFACTURERS

- A. Honeywell
- B. AprilAire
- C. ALOR AIR

2.2 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Seismic Performance: Dehumidification units 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.
- C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1.
- D. ASHRAE 62.1 Compliance: Section 5, "Systems and Equipment" and Section 7, "Construction and System Start-up."
- E. ASHRAE 15 Compliance: "Safety Standard for Refrigeration Systems."

2.3 CASINGS

- A. Casing: Single-wall construction with exterior steel or aluminum, stainless-steel fasteners, knockouts for electrical and piping connections, condensate drain connection, and lifting lugs.
 1. Access: Removable panels with neoprene compression gaskets and cam latches.
 2. Insulation: Minimum 2-inch-thick, glass-fiber-insulation fill or closed cell foam, with thermal breaks.
 3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- B. Drain Pan and Connection: Stainless steel insulated and complying with ASHRAE 62.1.

2.4 FANS

- A. Fans:
 1. Blades: Forward curved.
 2. Type: Housed centrifugal.
 3. Blade and Housing Material: Galvanized steel with baked-enamel finish.
- B. Fan Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
 1. Enclosure Type: Totally enclosed, fan cooled.

2.5 FILTERS

- A. Pleated:
 1. Thickness: Manufacturer's standard depth.
 2. MERV Rating: MERV 11, according to ASHRAE 52.2.

2.6 REFRIGERATION SYSTEM

- A. Energy Efficiency: Equal to or greater than prescribed by ASHRAE/IES 90.1.
- B. Refrigerant Coils with Multiple Refrigerant Circuits:
 1. Tubes: Copper.
 2. Fins:
 - a. Material: Aluminum or Copper.
 - b. Fin Spacing: Maximum **12** fins per inch.
 3. Fin and Tube Joints: Mechanical bond.
 4. Headers: Seamless-copper headers with brazed connections.
 5. Frames: Galvanized-steel frame.
 6. Coatings: Corrosion-resistant coating.
 7. Ratings: Designed, tested, and rated according to ASHRAE 33 and AHRI 410.

- C. Compressors: Hermetic, scroll compressors with integral vibration isolators and crankcase heaters that de-energize during compressor operation.

2.7 CONTROLS

- A. Control Panel: Integral service compartment containing fan-motor thermal and overload cutouts, compressor thermal and overload cutouts, 115-V control transformer if required, magnetic contactors for fan and compressor motors, and a nonfused factory-mounted and -wired disconnect switch for single external electrical power connection.
- B. Operating Control: Integral humidistat cycles the compressor. Humidistat shall incorporate fan on-off-auto switch.
- C. Operating Control: Factory-installed microprocessor controller.
 - 1. Display the following on the face of controller:
 - a. System on.
 - b. System dehumidifying mode.
 - 2. Provide access to the following set points on panel:
 - a. Space relative humidity.

2.8 SOURCE QUALITY CONTROL

- A. Verification of Performance: Factory test and rate dehumidification units according to AHRI 910.
- B. Sound-Power-Level Ratings: Factory test and rate dehumidification units according to AHRI 575.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine walls, floors, and roofs for suitable conditions where dehumidification units will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Equipment Mounting:
 - 1. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

3.3 PIPING CONNECTIONS

- A. Where piping is installed adjacent to dehumidification units, allow space for service and maintenance of dehumidification units.
- B. Connect piping to dehumidification units mounted on vibration isolators with flexible connectors.
- C. Connect condensate drain pans using minimum NPS 3/4 copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan, and install cleanout at changes in direction.
- D. Duct installation requirements are specified in Section 233113 "Metal Ducts." Drawings indicate the general arrangement of ducts. The following are specific connection requirements:

3.4 ELECTRICAL CONNECTIONS

- A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Locate nameplate where easily visible. Provide sticker label on grid below equipment.

3.5 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring between control devices.
- C. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.6 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Dehumidification unit will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

3.7 CLEANING

- A. Clean dehumidification units internally, on completion of installation, according to manufacturer's written instructions. Clean fan interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheels, cabinets, and coils' entering-air face.
- B. After completing system installation, testing, and startup service of dehumidification units, clean filter housings and install new filters.

3.8 ADJUSTING

- A. Adjust initial humidity set points.

3.9 STARTUP SERVICE

- A. Perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
- B. Perform the following final checks before startup:
 - 1. Verify that shipping, blocking, and bracing are removed.
 - 2. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
 - 3. Perform cleaning and adjusting specified in this Section.
 - 4. Check lubrication of bearings, pulleys, belts, and other moving parts.

- 5. Install clean filters.
- C. Starting procedures for dehumidification units include the following:
 - 1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Replace malfunctioning motors, bearings, and fan wheels.
 - 2. Measure and record motor's electrical values for voltage and amperage.
- D. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing of dehumidification unit.
- E. Startup Report: Report findings during startup. Identify startup steps, corrective measures taken, and final results.

END OF SECTION 23 84 16

SECTION 26 05 00 - COMMON WORK RESULTS FOR ELECTRICAL**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 the work of this section.

1.2 DESCRIPTION

- A. The work of this section includes the furnishing and installation of all electrical equipment, materials and devices as shown on the electrical drawings and/or as specified herein, including but not limited to:
1. Conduit and Wire
 2. Safety Switches and Fuses
 3. Lighting and Distribution Panelboards
 4. Wiring Devices
 5. Lighting
 6. Generators and Transfer Switches
 7. Photo-Voltaic Systems
 8. Fire Alarm Systems
- B. The term "provide" shall mean furnish and install.
- C. Applicable Publications:
1. Where publications are listed in each Section, they form a part of that Section to the extent referenced.
 2. When a standard is specified by reference, comply with the requirements and recommendations stated in that standard, except when its requirements are modified by the Contract Documents or applicable codes establish stricter standards.
 3. When a code is not specified by reference in a Section, the work of that Section shall comply with applicable codes listed in the General Conditions.
 4. The publication date is the publication in effect as of the bid date, except when a specific publication date is specified.
 5. Obtain copies of referenced standards direct from publication source, when needed for proper performance of work, or when required for submittal by Contract Documents.

1.3 QUALITY ASSURANCE

- A. Codes and Standards:
1. The installation of all work under this section shall comply with all applicable codes, laws, standards and regulations. Nothing in the specifications shall be construed to permit deviation from these governing items.
 2. Electrical material and equipment shall bear the UL label except where UL does not label such types of material and equipment. Materials, equipment and installation shall meet requirements of applicable codes and standards listed below:

National Electric Code	NEC
National Electrical Safety Code	NESC
Electrical Testing Lab	ETL
Underwriters Laboratories, Inc.	UL
Certified Ballast Manufacturing	CBM
National Electrical Manufacturers Association	NEMA

Illuminating Engineering Society	IES
Institute of Electrical and Electronic Engineers	IEEE
American National Standards Institute	ANSI

B. Qualifications of Workmen:

1. Provide sufficient qualified journeyman electricians who are thoroughly experienced with the materials and methods specified and familiar with the design requirement.
2. At least one qualified journeyman shall be present at all times during the execution of the work.
3. In acceptance or rejection in any portion of the electrical work, no allowance will be made for lack of skill on the part of the workmen.

1.4 INTENT OF DRAWINGS AND SPECIFICATIONS

- A. The implied and stated intent of the drawings and specifications is to establish minimum acceptable quality standards for materials, equipment and workmanship, and to provide operable electrical and mechanical systems in every respect.
- B. The drawings are diagrammatic only, intending to show general arrangement and location of system components. Due to the small scale of the drawings, and to unforeseen job conditions, all required offsets and fittings may not be shown, but shall be provided at no change in contract price.
- C. All work shall be accurately laid out and coordinated with other trades to avoid conflicts and to provide maximum accessibility for operation and maintenance.

1.5 SUBMITTALS

- A. Submit shop drawings of the electrical materials to the Designer for review in accordance with the provisions of Division 01 of these specifications.
- B. The following is a list of those items required to be submitted:
 1. Wiring Devices and Floor Boxes
 2. Wire, Conduit, Boxes.
 3. Panelboards.
 4. Safety Switches.
 5. Lighting and Lighting Control
 6. Surge Suppression
 7. Photo-Voltaic Systems
 8. Generators, Transfer Switches and SCADA System
 9. Fire Alarm Systems
- C. Contractor shall not begin fabrication or work which requires submittals until return of submittals.

1.6 SUBSTITUTIONS

- A. Refer to the appropriate Division 01 Specification for requirements on Substitutions.

1.7 VISIT TO THE SITE

- A. All persons proposing to submit quotations for work in accordance with these plans and specifications are expected to visit the site of the work covered by the plans and specifications and are to familiarize themselves with existing conditions as they affect the work of this section of the specifications. Claims resulting from a failure to visit the site or inspect the existing conditions will not be considered.

1.8 OPERATING AND MAINTENANCE DATA

- A. Compile product data and related information appropriate for Owner's maintenance and operation of products furnished under Contract.

1. Prepare operating and maintenance data as specified in this section and as referenced in the General Conditions and applicable Section of Division 01 General Requirements.
- B. Instruct Owner's personnel in maintenance of products and in operation of equipment and systems.
- C. Preparation of data shall be done by personnel:
 1. Trained and experienced in maintenance and operation of desired products.
 2. Familiar with requirements of this Section.
 3. Skilled as technical writer to the extent required to communicate essential data.
 4. Skilled as draftsman competent to prepare required drawings.
- D. Prepare data in form of an instructional manual for use by Owner's personnel.

1.9 PAINTING

- A. Suitable finish coatings shall be provided under this section of the Specifications on all items of electrical equipment and wiring which are exposed. This shall consist of either an approved factory applied finish or an acceptable finish applied during or after installation. Equipment which is furnished in finishes such as stainless steel or satin aluminum is not to be painted. Exposed equipment and/or wiring in finished areas such as panel covers or surface raceway shall be supplied with factory applied prime coat and shall be professionally painted or enameled as directed to result in a completely coated and attractively finished manner. All such finishing shall be as directed and shall be satisfactory to the Architect/Engineer.
- B. All factory finished steel surfaces; boxes, enclosures, etc., shall be cleaned and retouched or repainted as necessary to provide a rust resistant coating. Where painting or galvanizing is not specifically specified, ferrous devices, bolts, nuts, inserts, etc., shall be galvanized.
- C. All nameplates shall be left unpainted and in a clean condition.

1.10 WIRING AND ELEMENTARY DIAGRAMS

- A. Wiring and elementary diagrams for equipment as shown on the drawings are based on the product of the specified equipment manufacturer and are shown for convenience to aid in estimating the extent of the work involved. The equipment actually installed shall be wired and connected in accordance with the equipment manufacturer's recommendations and shall conform to details in approved wiring diagrams to be furnished by the equipment manufacturer. All equipment so connected shall be made to operate in a safe, proper and efficient manner. Note that control circuitry is not necessarily shown on the drawings but shall be installed in conduit between the points and devices indicated on the diagrams.

1.11 EQUIPMENT TESTS

- A. An operating test of the complete electrical system shall be made. System shall test free from grounds, shorts and other faults. Connections shall be for positive mechanical and electrical connection and continuity. Equipment shall be demonstrated to operate in accordance with the requirements of the plans and specifications. Contractor shall furnish all personnel and test instruments required. Performance of tests shall be made in the presence of the Owner's representative, where requested.
- B. The following tests shall be performed as a minimum:
 1. Control and Distribution Equipment:
 - a. Check the wire terminals, clean connections.
 - b. Check all control switches, alarm devices, indicating instruments for proper operation under normal and simulated abnormal conditions.
 2. Phase rotation: The connections of all equipment shall be checked for correct phase rotation.
 3. Circuit Breakers: The following tests shall be performed:

- a. Inspect each circuit breaker.
 - b. Check for loose connections.
 - c. Operate each circuit breaker manually.
 - d. Set the adjustable trips to the values specified.
- C. Spot-checks and/or back-checks to verify the testing accuracy shall be made for the Engineer or his agent during job-site visits.
- D. Validity of the ground path shall be assured by constant and careful attention to the thorough tightening of all couplings, connectors, locknuts, screws, bolts, etc. and by frequent checking of the path resistance with a quality low-range ohmmeter. Resistance of the path should not exceed one ohm between any two points. If a reading in excess of this is observed, it shall be discussed with the Engineer for an appraisal of the condition.
- E. After all fixtures, devices and equipment are installed and all connections completed to each panel – disconnect neutral feeder conductor from neutral bar and take a megger reading between neutral bar and grounded can. If this reading is less than 250,000 ohms, disconnect branch circuit (or sub-feeder) neutral wires from this neutral bar. Test each one separately to the panel can until low reading ones are found. Correct troubles reconnect and retest until at least 250,000 ohms from neutral bar to grounded panel can is achieved with only neutral feeder disconnected. In addition all wiring shall be tested. All phase and neutral conductors shall be tested with a 500 volt megger. Minimum acceptable readings shall be 1,000,000 ohms for conductors #6 awg and smaller; 250,000 ohms for conductors #4 awg and larger. All measurements shall be between the conductor and the grounding conductor.
- F. Upon completion of work, but before final inspection, the Contractor shall send a letter to the engineer and the Owner certifying that these tests have been accomplished and tabulating the megger readings for each panel. During field visits, contractor shall demonstrate installation and make such tests as may be required to satisfy the Designer and Owner that work is installed in accordance with drawings, specifications and instructions.

1.12 WARRANTIES

- A. All equipment installed under this Division of the work shall be warranted for a minimum of one year after project acceptance.
- B. During this warranty period, replace any and all defective equipment and parts at no cost to the Owner.

1.13 BRANCH CIRCUITS

- A. The number of conductors in each run of conduit is indicated on the drawings and where there is a conflict between the number of wires indicated and the actual number required as determined by the functional design requirements, the number of wires determined by the functional design requirements shall govern.
- B. In general, there is a number associated with each branch circuit outlet which identifies the particular branch circuit to which the device served by the outlet is to be connected. The circuit number indicated has been assigned only for reference and guidance, and is not intended to limit panelboard circuitry. All branch circuits shall be connected to breakers in accordance with circuit requirements and good industry practice. The balancing of all loads shall be included in the work of this DIVISION.
- C. Home runs shall not be combined where such would require derating of conductor ampacity. Separate neutrals shall be provided for all branch circuits.

1.14 MOTOR, APPLIANCE AND EQUIPMENT CONNECTIONS

- A. Unless otherwise shown on the drawings or specified herein, it is the intent of this DIVISION to provide all electrical equipment and connections required to protect, properly operate, and control all motors, appliances, electrical devices, and equipment

furnished and installed under this and other DIVISIONS of the specifications or shown on the drawings.

1.15 SETTING OF EQUIPMENT

- A. The setting of equipment shall be carefully coordinated with the work and requirements of the other trades involved to ensure compatibility and to avoid conflicts.
- B. Equipment, base mounted on concrete or masonry slabs, pads and piers, or mounted on stands, gratings, platforms, or other, shall not be set in any manner, except on the finished and permanent support.
- C. Support of equipment on studs or by other means, and the placing or building of the supporting slab, pad, pier, stand, grading, or other, "to the equipment", is prohibited.

1.16 ACCESS DOORS

- A. Where inaccessible ceilings or wall spaces are encountered by the Contractor and there is a need for access to junction boxes or other equipment as required by the NEC, the contractor shall provide any and all access doors at no additional cost. Doors shall be sized to meet the requirements of the work to be installed. Provide doors per Section 08 Access Doors and Frames.

1.17 RECORD DRAWINGS/MANUALS

- A. Upon completion of the installation, Contractor shall submit to the Designer marked prints of drawings showing any changes made in circuits, location of equipment, panelboards or any other revision in the Contract Drawings, for the Owner's use in maintenance work and for future additions and expansions. Marked changes shall also include changes due to change orders unless already recorded by revised drawing or bulletin drawing. **Underground conduit installations shall be dimensioned from a fixed point(s) on the drawings in all three (3) dimensions.**
- B. These records shall be submitted in one of two formats: either a clean, legible, marked set of prints with all markings in distinguishable colored pencil such as red; or a set of reverse-run reproducible sepia prints marked in soft pencil so that blue-line prints can be reproduced as required. The format to be used shall be as defined in the General Requirements section of the contract documents. If no format is defined, the marked blue-line prints shall be submitted.
- C. Operation and Maintenance manuals shall be submitted to the Designer at 80% completion. Information included shall be a copy of all submittal data, shop drawings and necessary operating and maintenance instructions and wiring diagrams on all major items of equipment and all special systems (fire alarm, intercom, etc.). Submit these manuals in the quantities and format described in the General Requirements section.

END OF SECTION 26 05 00

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SECTION 26 05 19 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES**PART 1 - GENERAL****1.1 SUMMARY**

- A. This Section includes the following:
 - 1. Building wires and cables rated 600 V and less.
 - 2. Connectors, splices, and terminations rated 600 V and less.
 - 3. Sleeves and sleeve seals for cables.

1.2 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Field quality-control test reports.

1.3 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with NFPA 70.

PART 2 - PRODUCTS**2.1 CONDUCTORS AND CABLES**

- A. Copper Conductors: Comply with NEMA WC 70.
- B. Conductor Insulation: Comply with NEMA WC 70 for Types THW, and THHN-THWN.

2.2 CONNECTORS AND SPLICES

- 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. AFC Cable Systems, Inc.
 - 2. Hubbell Power Systems, Inc.
 - 3. O-Z/Gedney; EGS Electrical Group LLC.
 - 4. 3M; Electrical Products Division.
 - 5. Tyco Electronics Corp.
- B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

2.3 SLEEVES FOR CABLES

- A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
- B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
- C. Coordinate sleeve selection and application with selection and application of firestopping specified in Specification Section "Firestopping."

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 **except stranded wire shall be provided where wiring is connected to vibrating equipment**; stranded for No. 8 AWG and larger.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

- A. Exposed Feeders: Type THHN-THWN, single conductors in raceway.
- B. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspace: Type THHN-THWN, single conductors in raceway.
- C. Feeders Concealed in Concrete, below Slabs-on-Grade, and underground: Type THHN-THWN, single conductors in raceway.
- D. Exposed Branch Circuits, Including in Crawlspace: Type THHN-THWN, single conductors in raceway.
- E. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway.
- F. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and underground: Type THHN-THWN, single conductors in raceway.
- G. Class 1 Control Circuits: Type THHN-THWN, in raceway.
- H. Class 2 Control Circuits: Type THHN-THWN, in raceway.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

- A. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.
- B. 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.
- C. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
- D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
- E. Support cables according to Division 26 Sections "Hangers and Supports for Electrical Systems."
- F. Identify and color-code conductors and cables according to Division 26 Section "Identification for Electrical Systems."
- G. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
- H. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
- I. Wiring at Outlets: Install conductor at each outlet, with at least 12 inches (300 mm) of slack.

3.4 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Coordinate sleeve selection and application with selection and application of firestopping specified in Specification Section "Firestopping."
- B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

- C. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
- D. Cut sleeves to length for mounting flush with both wall surfaces.
- E. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level.
- F. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and cable unless sleeve seal is to be installed.
- G. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies.
- H. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and cable, using joint sealant appropriate for size, depth, and location of joint according to Specification Section "Joint Sealants."
- I. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at cable penetrations. Install sleeves and seal with firestop materials according to Specification Section "Penetration Firestopping."
- J. Roof-Penetration Sleeves: Seal penetration of individual cables with flexible boot-type flashing units applied in coordination with roofing work.
- K. Aboveground Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Size sleeves to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- L. Underground Exterior-Wall Penetrations: Install cast-iron "wall pipes" for sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between cable and sleeve for installing mechanical sleeve seals.

3.5 SLEEVE-SEAL INSTALLATION

- A. Install to seal underground exterior-wall penetrations.
- B. Use type and number of sealing elements recommended by manufacturer for cable material and size. Position cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.6 FIRESTOPPING

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

3.7 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
- B. Tests and Inspections:
 - 1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors, and conductors feeding the following critical equipment and services for compliance with requirements of other sections.
- C. Test Reports: Prepare a written report to record the following:
 - 1. Test procedures used.
 - 2. Test results that comply with requirements.
 - 3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.
- D. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 26 05 19

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SECTION 26 05 26 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes methods and materials for grounding systems and equipment.

1.2 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Field quality-control test reports.

1.3 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.1 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.

2.2 CONNECTORS

- A. Listed and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction for applications in which used, and for specific types, sizes, and combinations of conductors and other items connected.
- B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, bolted pressure-type, with at least two bolts.
 - 1. Pipe Connectors: Clamp type, sized for pipe.
- C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

2.3 GROUNDING ELECTRODES

- A. Ground Rods: Copper-clad steel; 3/4 inch by 10 feet (19 mm by 3 m) in diameter.

PART 3 - EXECUTION

3.1 APPLICATIONS

- A. Conductors: Install solid conductor for No. 10 AWG and smaller, and stranded conductors for No. 8 AWG and larger, unless otherwise indicated.

3.2 EQUIPMENT GROUNDING

- A. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
 - 1. Feeders and branch circuits.
 - 2. Single-phase motor and appliance branch circuits.
 - 3. Three-phase motor and appliance branch circuits.
 - 4. Flexible raceway runs.

3.3 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. **All grounding conductors shall be installed in raceways.**
- B. Ground Rods: Drive rods until tops are 2 inches (50 mm) 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.
- C. 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 so vibration is not transmitted to rigidly mounted equipment.
 - 3. Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.

3.4 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections and prepare test reports:
 - 1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
 - 2. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at ground test wells.
 - a. Measure ground resistance not less 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 with a ground resistance tester.
 - 3. Provide a report to the Designer showing all test values. Where values exceed 25 ohms to ground the contractor shall drive additional ground rods until a resistance of less than 25 ohms is achieved.

END OF SECTION 26 05 26

SECTION 26 05 29 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section includes:
 - 1. Hangers and supports for electrical equipment and systems.
 - 2. Construction requirements for concrete bases.

1.2 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Design supports for multiple raceways, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated where required in other sections.
- B. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.
- C. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
- D. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

1.3 SUBMITTALS

- A. Product Data: For steel slotted support systems.
- B. Shop Drawings: Show fabrication and installation details and include calculations for the following:
 - 1. Trapeze hangers. Include Product Data for components.
 - 2. Steel slotted channel systems. Include Product Data for components.
 - 3. Equipment supports.
- C. Welding certificates.

1.4 QUALITY ASSURANCE

- A. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Comply with NFPA 70.

PART 2 - PRODUCTS**2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS**

- A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.
 - 1. 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:
 - a. Allied Tube & Conduit.
 - b. Cooper B-Line, Inc.; a division of Cooper Industries.
 - c. ERICO International Corporation.
 - d. GS Metals Corp.
 - e. Thomas & Betts Corporation.

- f. Unistrut; Tyco International, Ltd.
 - g. Wesanco, Inc.
- 2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
- 3. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
- 4. Channel Dimensions: Selected for applicable load criteria.
- B. Raceway and Cable Supports: As described in NECA 1 and NECA 101.
- C. Conduit and Cable Support Devices: Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- D. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored 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 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.
 - 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) Hilti Inc.
 - 2) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
 - 3) MKT Fastening, LLC.
 - 4) Simpson Strong-Tie Co., Inc.; Masterset Fastening Systems Unit.
 - 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 in which used.
 - 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) Cooper B-Line, Inc.; a division of Cooper Industries.
 - 2) Empire Tool and Manufacturing Co., Inc.
 - 3) Hilti Inc.
 - 4) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
 - 5) MKT Fastening, LLC.
 - 3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
 - 4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
 - 5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
 - 6. Toggle Bolts: All-steel springhead type.
 - 7. Hanger Rods: Threaded steel.

2.2 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 Specification Section "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION**3.1 APPLICATION**

- A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.
- B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch (6 mm) in diameter.
- C. 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.
- D. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch (38-mm) and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.
- B. Raceway Support Methods: In addition to methods described in NECA 1, EMT may be supported by openings through structure members, as permitted in 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 (90 kg).
- 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 (100 mm) thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches (100 mm) thick.
 - 6. To Steel: Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69.
 - 7. To Light Steel: Sheet metal screws.
 - 8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate.
- E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

- A. Comply with installation requirements in Specification Section "Metal Fabrications" for site-fabricated metal supports.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- C. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 CONCRETE BASES

- A. Construct concrete bases of dimensions indicated but not less than 4 inches (100 mm) 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 (20.7-MPa), 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Specification Section "Cast-in-Place Concrete."
- C. Anchor equipment to concrete base.
 - 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 (0.05 mm).
- B. Touchup: Comply with requirements in Painting Specification Sections for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 26 05 29

SECTION 26 05 33 - RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS**PART 1 - GENERAL****1.1 SUMMARY**

- A. This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.

1.2 SUBMITTALS

- A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.
- B. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, details, and attachments to other work.

1.3 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with NFPA 70.

PART 2 - PRODUCTS**2.1 METAL CONDUIT AND TUBING**

- A. Rigid Steel Conduit: ANSI C80.1.
- B. EMT: ANSI C80.3.
- C. FMC: Zinc-coated steel.
- D. LFMC: Flexible steel conduit with PVC jacket.
- E. Fittings for Conduit (Including all Types and Flexible and Liquidtight), EMT, and Cable: NEMA FB 1; listed for type and size raceway with which used, and for application and environment in which installed.
 - 1. Fittings for EMT: Steel, compression, insulated throat type connectors.

2.2 BOXES, ENCLOSURES, AND CABINETS

- A. Sheet Metal Outlet and Device Boxes: NEMA OS 1.
- B. Cast-Metal Outlet and Device Boxes: NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.
- C. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- D. Cast-Metal Access, Pull, and Junction Boxes: NEMA FB 1, galvanized, cast iron with gasketed cover.
- E. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous-hinge cover with flush latch, unless otherwise indicated.
 - 1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

- A. Outdoors: Apply raceway products as specified below, unless otherwise indicated:
 - 1. Exposed Conduit: Rigid steel conduit.
 - 2. Concealed Conduit, Aboveground: Rigid steel conduit.
 - 3. Underground Conduit: Rigid Steel conduit, unless otherwise noted on the Drawings. Schedule 40 PVC may be used if encased in 3" (min) of concrete.
 - 4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
 - 5. Boxes and Enclosures, Aboveground: Type Nema 4X Stainless Steel.
- B. Comply with the following indoor applications, 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: Rigid steel conduit. Includes raceways in the following locations:
 - a. Apparatus Bay.
 - b. Mechanical rooms below 8'-0".
 - 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: Rigid steel conduit.
 - 7. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4, nonmetallic in damp or wet locations.
- C. Minimum Raceway Size 3/4-inch (21-mm) trade size, interior applications, and 1-inch for underground applications and interior telecommunications applications.
- D. **Raceway colors required by the Drawings shall be factory applied not field applied.**
- E. Raceway Fittings: Compatible with raceways and suitable for use and location.
 - 1. Rigid Steel Conduit: Use threaded rigid steel conduit fittings, unless otherwise indicated.
 - 2. EMT: Use steel compression fittings; connectors shall have insulated throats.

3.2 INSTALLATION

- A. Comply with NECA 1 for installation requirements applicable to products specified in Part 2 except where requirements on Drawings or in this Article are stricter.
- B. All raceways shall be installed parallel and perpendicular to the structure.
- C. 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.
- D. Complete raceway installation before starting conductor installation.
- E. Support raceways as specified in Division 26 Section "Hangers and Supports for Electrical Systems."
- F. Arrange stub-ups so curved portions of bends are not visible above the finished slab.
- G. Seal all raceway penetrations through walls or partitions with an appropriate sealant and paint to match the surrounding surfaces.
- H. Install no more than the equivalent of three 90-degree bends in any conduit run except for communications conduits, for which fewer bends are allowed.
- I. Conceal conduit and EMT within finished walls, ceilings, and floors, unless otherwise indicated.
- J. Raceways 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.

2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
- K. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors, including conductors smaller than No. 4 AWG.
- L. 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.
- M. Install raceway sealing fittings at suitable, approved, and accessible locations 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 at the following points:
 1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
 2. Where otherwise required by NFPA 70, including service entrance points (NEC230-8).
- N. Flexible Conduit Connections: Use maximum of 72 inches (1830 mm) of flexible conduit for recessed and semi-recessed lighting fixtures, 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 in damp or wet locations not subject to severe physical damage.
- O. 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.
- P. Where concentric, eccentric or over-sized knockouts are encountered, a grounding-type insulated bushing shall be provided.
- Q. GRC shall be terminated with either double lock nuts/bushings or in a threaded hub.
- R. The use of LBs shall be limited as much as possible. Where used for raceway larger than 2" in size, "mogul" type bodies shall be provided.
- S. Set metal floor boxes level and flush with finished floor surface.
- T. **No flexible conduits or condulets shall be used for Telecommunications cabling installation. In addition, pull boxes must be installed on all Telecommunications raceway where the number of bends exceeds 180 degrees between boxes.**
- U. **Boxes and Conduit shall be painted as identified in other sections of the specifications or as detailed on the Drawings. Circuit information on above ceiling boxes shall be clearly indicated with indelible marker on all lighting and power circuits. Identification shall be visible from below the box.**
- V. Division 26 shall provide accurate as-built drawings to the Division 27 (Telecom) and 28 (Security) installers prior to those installers beginning their work. Drawings shall accurately show the installed conditions of all conduits provided for their use.

END OF SECTION 26 05 33

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SECTION 26 05 48 - 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 forces required to select seismic restraints and for designing vibration isolation bases.
 - a. Coordinate design calculations with wind load calculations required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.
 - 3. Seismic-Restraint Details:
 - a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
 - b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
 - c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.

- d. Preapproval and Evaluation Documentation: 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. Panelboards.
 - 5. Generators and Transfer Switches
 - 6. Photovoltaic system components.
- 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. Seismic-Restraint Loading:
 - 1. Site Class as Defined in the IBC: D.
 - 2. Assigned Seismic Use Group or Building Category as Defined in the IBC: IV
 - a. Component Importance Factor: 1.5.
 - b. Component Response Modification Factor: 3.5.
 - c. Component Amplification Factor: 2.5.
 - 3. Design Spectral Response Acceleration at Short Periods (0.2 Second): 16.9%.
 - 4. Design Spectral Response Acceleration at 1.0-Second Period: 12.5%.

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 A603 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: Reinforcing steel angle clamped 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 E488.

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 E488.

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.
- 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 (3.2 mm).
 - 2. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.
- C. Install cables so they do not bend across edges of adjacent equipment or building structure.
- D. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.
- E. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.
- F. Drilled-in Anchors:
 - 1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
 - 2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
 - 3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
 - 4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
 - 5. Set anchors to manufacturer's recommended torque using a torque wrench.
 - 6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

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. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. 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.
- C. Seismic controls will be considered defective if they do not pass tests and inspections.
- D. 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 26 05 48

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SECTION 26 05 53 - IDENTIFICATION FOR ELECTRICAL SYSTEMS**PART 1 - GENERAL****1.1 SUMMARY**

- A. This Section includes the following:
 - 1. Identification for conductors and communication and control cable.
 - 2. Warning labels and signs.
 - 3. Equipment identification labels.

1.2 SUBMITTALS

- A. Product Data: For each electrical identification product indicated.

1.3 QUALITY ASSURANCE

- A. Comply with ANSI A13.1.

1.4 COORDINATION

- A. Coordinate identification names, abbreviations, colors, and other features with requirements in the Contract Documents, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual, and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.

PART 2 - PRODUCTS**2.1 CONDUCTOR AND COMMUNICATION- AND CONTROL-CABLE IDENTIFICATION MATERIALS**

- A. Marker Tape: Vinyl or vinyl -cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

2.2 WARNING LABELS AND SIGNS

- A. Comply with NFPA 70 and 29 CFR 1910.145.
- B. Self-Adhesive Warning Labels: Factory printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment, unless otherwise indicated.
- C. Baked-Enamel Warning Signs: Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application. 1/4-inch (6.4-mm) grommets in corners for mounting. Nominal size, 7 by 10 inches (180 by 250 mm).
- D. Metal-Backed, Butyrate Warning Signs: Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch (1-mm) galvanized-steel backing; and with colors, legend, and size required for application. 1/4-inch (6.4-mm) grommets in corners for mounting. Nominal size, 10 by 14 inches (250 by 360 mm).
- E. Fasteners for Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.
- F. Warning label and sign 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)."
3. Arc Flash Hazard Warning: "DANGER-ARC FLASH AND SHOCK HAZARD- APPROPRIATE PPE REQUIRED"
 - a. Label shall include a location for the following information to be written in by the Contractor; Flash Hazard Category, Min. Arc Rating, Flash Hazard Boundary.
 - b. Contractor shall refer to the riser diagram for this information and confer with the Designer at the end of the Project to confirm that the values are still valid. Contractor shall finalize labeling after receiving approval of the Designer.

2.3 EQUIPMENT IDENTIFICATION LABELS

- A. Engraved phenolic labels, lettering no less than 3/8" high.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Auxiliary Electrical Systems Conductor and Cable Identification: Use marker tape to identify field-installed alarm, control, signal, sound, intercommunications, voice, and data wiring connections.
 1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and cable pull points. Identify by system and circuit designation.
 2. Use system of designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
- B. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.
 1. Labeling Instructions:
 - a. Blue surface with white core for 208Y/120 volt equipment.
 - b. Red surface with white core for life safety equipment
 2. Equipment to Be Labeled:
 - a. Panelboards, electrical cabinets, and enclosures.
 - b. Enclosed circuit breakers and disconnect switches.
 - c. Motor starters and VFDs. Division 26 shall provide all labels.
 - d. Fire alarm panel.

3.2 INSTALLATION

- A. Verify identity of each item before installing identification products.
- B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.
- C. Apply identification devices to surfaces that require finish after completing finish work.
- D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.
- E. Attach non-adhesive signs and plastic labels with screws and auxiliary hardware appropriate to the location and substrate.
- F. **Paint conduit and boxes per Wake County Standards. Refer to the Drawings for additional information.**

- G. Color-Coding for Phase Identification, 600 V and Less: Use the colors listed below for ungrounded conductors.
 - 1. Color shall be factory applied.
 - 2. Colors for 208Y/120-V Circuits:
 - a. Phase A: Black.
 - b. Phase B: Red.
 - c. Phase C: Blue.
 - d. Neutral: White
 - e. Ground: Green

END OF SECTION 26 05 53

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SECTION 26 09 23 - LIGHTING CONTROL DEVICES**PART 1 - GENERAL****1.1 SUMMARY**

- A. This Section includes the following lighting control devices:
 - 1. Outdoor photoelectric switches.
 - 2. Indoor occupancy sensors.
 - 3. Lighting contactors.
- B. See Division 26 Section "Wiring Devices" for wall-box dimmers, wall-switch occupancy sensors, and manual light switches.

1.2 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Field quality-control test reports.
- C. Operation and maintenance data.

1.3 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

PART 2 - PRODUCTS**2.1 OUTDOOR PHOTOELECTRIC SWITCHES**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Intermatic, Inc.
 - 2. Acuity Lighting Group, Inc.
 - 3. Square D; Schneider Electric.
 - 4. TORK.
 - 5. Watt Stopper (The).
- B. Description: Solid state, with DPST dry contacts rated for 1800 VA to operate connected load, relay, or contactor coils; complying with UL 773.
 - 1. Light-Level Monitoring Range: 1.5 to 10 fc (16.14 to 108 lx), with an adjustment for turn-on and turn-off levels within that range.
 - 2. Time Delay: 30-second minimum, to prevent false operation.
 - 3. Lightning Arrester: Air-gap type.
 - 4. Mounting: Twist lock complying with IEEE C136.10, with base.

2.2 INDOOR OCCUPANCY SENSORS

- A. Subject to compliance with requirements, provide products by one of the following:
 - 1. Hubbell Lighting.
 - 2. Leviton Mfg. Company Inc.
 - 3. Sensor Switch, Inc.
 - 4. Watt Stopper (The).
- B. General Description: Wall- or ceiling-mounting, solid-state units with a separate relay unit.
 - 1. Operation: Unless otherwise indicated, turn lights on when covered area is occupied and off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.

2. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered from the relay unit.
 3. Relay Unit: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.
 4. 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.
 5. Indicator: LED, to show when motion is being detected during testing and normal operation of the sensor.
 6. Bypass Switch: Override the on function in case of sensor failure.
 7. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc (21.5 to 2152 lx); keep lighting off when selected lighting level is present.
- C. PIR Type: Ceiling mounting; detect occupancy by sensing a combination of heat and movement in area of coverage.
1. 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).
 2. Detection Coverage (Room): Detect occupancy anywhere in a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.
 3. Detection Coverage (Corridor): Detect occupancy within 90 feet (27.4 m) when mounted on a 10-foot- (3-m-) high ceiling.

2.3 LIGHTING CONTACTORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Eaton Electrical Inc.; Cutler-Hammer Products.
 2. GE Industrial Systems; Total Lighting Control.
 3. Hubbell Lighting.
 4. Lithonia Lighting; Acuity Lighting Group, Inc.
 5. Square D; Schneider Electric.
 6. TORK.
- B. Description: Electrically operated and electrically held, complying with NEMA ICS 2 and UL 508.
1. Current Rating for Switching: Listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballast with 15 percent or less total harmonic distortion of normal load current).
 2. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation.
 3. Enclosure: Comply with NEMA 250.

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 Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 SENSOR INSTALLATION

- A. 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.

- B. When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting sensors to suit actual occupied conditions. Provide up to **two** visits to Project during other than normal occupancy hours for this purpose.

3.2 CONTACTOR INSTALLATION

- A. 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.

3.3 WIRING INSTALLATION

- A. Wiring Method: Comply with Division 26 Section "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size shall be 3/4 inch .
- B. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.
- C. Size conductors according to lighting control device manufacturer's written instructions, unless otherwise indicated.
- D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.4 IDENTIFICATION

- A. Identify components and power and control wiring according to Division 26 Section "Identification for Electrical Systems."
 - 1. Identify controlled circuits in lighting contactors.
 - 2. Identify circuits or luminaries controlled by photoelectric and occupancy sensors at each sensor.
- B. Label time switches and contactors with a unique designation.

3.5 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
 - 1. After installing time switches and sensors, and after electrical circuitry has been energized, adjust and test for compliance with requirements.
 - 2. Operational Test: Verify operation of each lighting control device, and adjust time delays.
- B. Lighting control devices that fail tests and inspections are defective work.

END OF SECTION 26 09 23

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SECTION 26 24 16 - PANELBOARDS**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section includes distribution panelboards and lighting and appliance branch-circuit panelboards.

1.2 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: For each panelboard 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.
 - 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. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
 - 7. Include wiring diagrams for power, signal, and control wiring.
 - 8. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards.
- C. Field quality-control reports.
- D. Panelboard schedules for installation in panelboards.
- E. Operation and maintenance data.

1.3 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with NEMA PB 1.
- C. Comply with NFPA 70.

PART 2 - PRODUCTS**2.1 GENERAL REQUIREMENTS FOR PANELBOARDS**

- A. Enclosures: Flush- and surface-mounted cabinets.
 - 1. Rated for environmental conditions at installed location.
 - a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
 - b. Outdoor Wet and Damp Locations: NEMA 250, Type 4X Stainless Steel.
 - 2. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box.
 - 3. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.
 - 4. Directory Card: Inside panelboard door, mounted in transparent card holder.
- B. Incoming Mains Location: Top and bottom.
- C. Phase, Neutral, and Ground Buses: Hard-drawn copper, 98 percent conductivity.
- D. 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.
- 3. Ground Lugs and Bus Configured Terminators: Mechanical type.
- E. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.
- F. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals.

2.2 DISTRIBUTION PANELBOARDS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - 3. Square D; a brand of Schneider Electric.
- B. Panelboards: NEMA PB 1, power and feeder distribution type.
- C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
- D. Branch Overcurrent Protective Devices: For Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.
- E. Branch Overcurrent Protective Devices: For Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers; plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.

2.3 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - 3. Square D; a brand of Schneider Electric.
- B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.
- C. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.
- D. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

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. Molded-Case Circuit-Breaker (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 materials.
 - c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
 - d. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Receive, inspect, handle, store and install panelboards and accessories according NEMA PB 1.1.
- B. Mount top of trim 72 inches above finished floor unless otherwise indicated.

- C. Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.
- D. Where two or three single pole breakers serve a multi-wire circuit, provided identifying handle ties on those breakers serving the circuit to meet provisions of NEC 210.4 (B).
- E. Install overcurrent protective devices and controllers not already factory installed.
 - 1. Set field-adjustable, circuit-breaker trip ranges.
- F. Install filler plates in unused spaces.
- G. Stub four 1-inch (27-GRC) empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch (27-GRC) empty conduits into raised floor space or below slab not on grade.
- H. Arrange conductors in gutters into groups and bundle and wrap with wire ties.
- I. Comply with NECA 1.

3.2 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Division 16 Section "Identification for Electrical Systems."
- B. Create a directory to indicate installed circuit loads and incorporating Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.
- C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.3 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Acceptance Testing Preparation:
 - 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 visual tests of all panelboards, cleaning any construction debris before energizing and before final inspection.
 - 2. Check all phases for load balance, balancing all phases to within 20% of each other.
 - 3. Provide thermal scan of all panelboards when they have been operating at maximum load for a minimum of one (1) hour. Record all "hot spots" and make corrections as necessary. Any corrections that cannot be accomplished on site shall be brought to the Designer's attention. Failure of panelboard components shall be rectified by the Contractor and/or panelboard vendor.
- D. Panelboards will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection report, including a certified report that identifies panelboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken and observations after remedial action.

END OF SECTION 26 24 16

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SECTION 26 27 26 - WIRING DEVICES**PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Receptacles, receptacles with integral GFCI, and associated device plates.
 - 2. Wall-box motion sensors.
 - 3. Snap switches and wall-box dimmers.
 - 4. Wall-switch and exterior occupancy sensors.
 - 5. Floor service outlets, poke-through assemblies, service poles, and multioutlet assemblies.

1.3 DEFINITIONS

- A. EMI: Electromagnetic interference.
- B. GFCI: Ground-fault circuit interrupter.
- C. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.
- C. Samples: One for each type of device and wall plate specified, in each color specified.
- D. Field quality-control test reports.
- E. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing label warnings and instruction manuals that include labeling conditions.

1.5 QUALITY ASSURANCE

- A. Source Limitations: Obtain each type of wiring device and associated wall plate through one source from a single manufacturer. Insofar as they are available, obtain all wiring devices and associated wall plates from a single manufacturer and one source.
- B. 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.
- C. Comply with NFPA 70.

1.6 COORDINATION

- A. Receptacles for Owner-Furnished Equipment: Match plug configurations.
 - 1. Cord and Plug Sets: Match equipment requirements.

PART 2 - PRODUCTS**2.1 MANUFACTURERS**

- A. Manufacturers' Names: Shortened versions (shown in parentheses) of the following manufacturers' names are used in other Part 2 articles:
 - 1. Cooper Wiring Devices; a division of Cooper Industries, Inc. (Cooper).
 - 2. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).
 - 3. Leviton Mfg. Company Inc. (Leviton).
 - 4. Pass & Seymour/Legrand; Wiring Devices & Accessories (Pass & Seymour).

2.2 STRAIGHT BLADE RECEPTACLES

- A. Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.

2.3 GFCI RECEPTACLES

- A. General Description: Straight blade, feed-through type. Comply with NEMA WD 1, NEMA WD 6, UL 498, and UL 943, Class A, and include indicator light that is lighted when device is tripped.

2.4 SNAP SWITCHES

- A. Comply with NEMA WD 1 and UL 20.

2.5 DIMMERS

- A. Wall-Box Dimmers:
 - 1. Description: Modular, full-wave, solid-state dimmer switch with integral, quiet on-off switches, with audible frequency and EMI/RFI suppression filters.
 - 2. Control: Continuously adjustable slider; with single-pole or three-way switching.
 - 3. Standards: Comply with UL 1472.
 - 4. Incandescent Lamp Dimmers: 120 V; control shall follow square-law dimming curve. On-off switch positions shall bypass dimmer module.
 - a. 600/1000 W; dimmers shall require no derating when ganged with other devices. Illuminated when "off."
 - 5. LED Lamp Dimmer Switches: Modular; compatible with LED drivers.

2.6 OCCUPANCY SENSORS

- A. Wall-Switch Sensors:
 - 1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Hubbell
 - b. Leviton
 - c. Sensor Switch
 - d. Wattstopper
 - 2. Description: Adaptive-technology type, 120/277 V, adjustable time delay up to 20 minutes, 180-degree field of view, with a minimum coverage area of 900 sq. ft. (84 sq. m).

2.7 WALL PLATES

- A. Single and combination types to match corresponding wiring devices.
 - 1. Plate-Securing Screws: Metal with head color to match plate finish.
 - 2. Material for Finished Spaces: 0.035-inch- (1-mm-) thick, satin-finished stainless steel.
 - 3. Material for Unfinished Spaces: Galvanized steel.

4. Wet/Damp-Location, Weatherproof Cover Plates: NEMA 250, complying with type 3R weather-resistant, metallic with lockable cover.

2.8 FLOOR SERVICE FITTINGS (TYPE FB-1 BOX)

- A. Flush-Type Floor Service Fittings:
 1. Description: Type: Modular, flush-type, three-service units suitable for wiring method used, with cover flush with finished floor.
 2. Compartments: Barrier separates power from voice and data communication cabling.
 3. Service Plate and Cover: Rectangular, die-cast aluminum with satin finish.
 4. Power Receptacle: NEMA WD 6 Configuration 5-20R, gray finish, unless otherwise indicated.
 5. Data Communication Outlet: Blank cover with bushed cable opening.
 6. AV Communication Outlet: Blank cover with bushed cable opening.

2.9 FLOOR SERVICE FITTINGS (TYPE PT-1 BOX)

- A. Flush-Type Floor Service Fittings:
 1. Description: Type: Modular, flush-type, dual-service units suitable for wiring method used, with cover flush with finished floor.
 2. Compartments: Barrier separates power from voice and data communication cabling.
 3. Service Plate and Cover: Round, die-cast aluminum with satin finish.
 4. Power Receptacle: 1" furniture feed.
 5. Data Communication Outlet: Blank cover with bushed cable opening.

2.10 FLOOR SERVICE FITTINGS (TYPE PT-2 BOX)

- A. Flush-Type Floor Service Fittings:
 1. Description: Type: Modular, flush-type, dual-service units suitable for wiring method used, with cover flush with finished floor.
 2. Compartments: Barrier separates power from voice and data communication cabling.
 3. Service Plate and Cover: Rectangular, die-cast aluminum with satin finish.
 4. Power Receptacle: Two (2) 20 ampere 120 volt receptacles.
 5. Data Communication Outlet: Blank cover with bushed cable opening.

2.11 FINISHES

- A. Color: Wiring device catalog numbers in Section Text do not designate device color.
 1. Wiring Devices Connected to Normal Power System: **Gray finish.**

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with NECA 1, including the mounting heights listed in that standard, unless otherwise noted.
- B. Coordination with Other Trades:
 1. Take steps to insure that devices and their boxes are protected. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of the boxes.

2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
 3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
 4. Install wiring devices after all wall preparation, including painting, is complete.
- C. Conductors:
1. Do not strip insulation from conductors until just before they are spliced or terminated on devices.
 2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
 3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
- D. Device Installation:
1. Replace all devices that have been in temporary use during construction or that show signs that they were installed before building finishing operations were complete.
 2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
 3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
 4. Connect devices to branch circuits using pigtails that are not less than 6 inches (152 mm) in length.
 5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, 2/3 to 3/4 of the way around terminal screw.
 6. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
 7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
 8. Tighten unused terminal screws on the device.
 9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.
- E. Receptacle Orientation:
1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the right.
- F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.
- G. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.
- H. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

3.2 IDENTIFICATION

- A. Comply with Division 26 Section "Identification for Electrical Systems."
1. Receptacles: Identify panelboard and circuit number from which served per details. Use durable wire markers or tags inside outlet boxes.

3.3 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
1. Test Instruments: Use instruments that comply with UL 1436.
 2. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated LED indicators of measurement.

- B. Tests for Convenience Receptacles:
1. Line Voltage: Acceptable range is 105 to 132 V.
 2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is not acceptable.
 3. Ground Impedance: Values of up to 2 ohms are acceptable.
 4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
 5. Using the test plug, verify that the device and its outlet box are securely mounted.
 6. The tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

END OF SECTION 26 27 26

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SECTION 26 28 16 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes:
 - 1. Fusible switches.
 - 2. Non-fusible switches.

1.2 DEFINITIONS

- A. NC: Normally closed.
- B. NO: Normally open.
- C. SPDT: Single pole, double throw.

1.3 SUBMITTALS

- A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated.
- B. Shop Drawings: For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Wiring Diagrams: For power, signal, and control wiring.
- C. Field quality-control reports.
- D. Operation and maintenance data.

1.4 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified third party testing agency, and marked for intended location and application.
- B. Comply with NFPA 70.

PART 2 - PRODUCTS**2.1 FUSIBLE SWITCHES**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - 3. Square D; a brand of Schneider Electric.
- B. Type HD, Heavy Duty, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate fuses, lockable handle with capability to accept three padlocks, and provided with a defeatable interlock with cover in closed position.
- C. Accessories:
 - 1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
 - 2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
 - 3. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.

4. Lugs: Suitable for number, size, and conductor material.
5. Auxiliary Form C contact that changes state based on position of handle.

2.2 NONFUSIBLE SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 3. Square D; a brand of Schneider Electric.
- B. Type HD, Heavy Duty, 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 provided with a defeatable interlock with cover in closed position.
- C. Accessories:
 1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
 2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
 3. Lugs: Suitable for number, size, and conductor material.
 4. Auxiliary Form C contact that changes state based on position of handle.

2.3 ENCLOSURES

- A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.
 1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
 2. **Outdoor Locations: NEMA Type 4X, Stainless Steel.**

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.
- B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- C. Install fuses in fusible devices.
- D. Comply with NECA 1.

3.2 IDENTIFICATION

- A. Comply with requirements in Division 26 Section "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.

3.3 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Acceptance Testing Preparation:
 1. Test insulation resistance for each enclosed switch and circuit breaker, 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 stated in NETA Acceptance Testing Specification. 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. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection report, including a certified report that identifies enclosed switches and circuit breakers and that describes scanning results. Include notation of deficiencies detected, remedial action taken and observations after remedial action.

END OF SECTION 26 28 16

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SECTION 26 31 00 - PHOTOVOLTAIC COLLECTORS**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. Section Includes:
 - 1. PV Systems Description.
 - 2. Manufactured PV Units.
 - 3. PV Module Framing.
 - 4. PV Array Construction.
 - 5. Power Optimizer.
 - 6. Combiner Disconnect Switch.
 - 7. Inverter.
 - 8. System Overcurrent Protection.
 - 9. Mounting Structures.

1.3 DEFINITIONS

- A. ETFE: Ethylene tetrafluoroethylene.
- B. FEP: Fluorinated ethylene propylene.
- C. IP Code: Required ingress protection to comply with IEC 60529.
- D. MPPT: Maximum power point tracking.
- E. PTC: PVUSA Test Condition. Commonly regarded as a "real-world" measure of PV output. See below for definition of "PVUSA."
- F. PV: Photovoltaic.
- G. PVUSA: Photovoltaics for Utility Systems Applications.
- H. STC: Standard Test Conditions defined in IEC 61215.

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 PV panels.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings: For PV modules.
 - 1. Include plans, elevations, sections, and mounting 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. Detail fabrication and assembly.
 - 4. Include diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

- B. Sample Warranty: For manufacturer's special materials and workmanship warranty and minimum power output warranty.
- C. Provide copy of NABCEP certification for solar installer.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For PV modules to include in operation and maintenance manuals.

1.7 WARRANTY

- A. Manufacturer's Special Warranty: Manufacturer agrees to repair or replace components of PV modules that fail in materials or workmanship within specified warranty period.
 - 1. Manufacturer's materials and workmanship warranties include, but are not limited to, the following:
 - a. Faulty operation of PV modules.
 - 2. Warranty Period: Twelve (12) years from date of Substantial Completion.
- B. Manufacturer's Special Minimum Power Output Warranty: Manufacturer agrees to repair or replace components of PV modules that fail to exhibit the minimum power output within specified warranty period. Special warranty, applying to modules only, applies to materials only, on a prorated basis, for period specified.
 - 1. Manufacturer's minimum power output warranties include, but are not limited to, the following warranty periods, from date of Substantial Completion:
 - a. Specified minimum power output to 80 percent or more, for a period of 25 years.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

- A. PV Modules:
 - 1. SolarWorld
 - 2. Q-Cells.
 - 3. Or Engineer approved equal.
- B. Inverter: Solaredge, SE xx US or Engineer approved equal.
- C. Substitutions shall be in accordance with General Conditions and Instruction to Bidders.

2.2 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3 PV CAPACITIES AND CHARACTERISTICS

- A. Minimum Electrical Characteristics:
 - 1. Rated Open-Circuit Voltage: 47 V dc.
 - 2. Maximum System Voltage: 37.1 V dc.
 - 3. Maximum Power at Voltage (Vpm): 257.3 V dc.
 - 4. Short-Circuit Temperature Coefficient: 2.9 mA/deg C.
 - 5. Rated Short-Circuit Current (Isc): 9.81 A.
 - 6. Maximum System: 1000 V dc.
 - 7. Rated Operation Current (Imp): 9.26 A.
 - 8. Maximum Power at STC (Pmax): 540 watts.

- B. Normal Operating Temperature Characteristics (NOTC):
 - 1. Temperature at Nominal Operating Cell Temperature: 46 deg C.
 - 2. Temperature Coefficient (NOTC Nominal Power): -19.32 deg C.
 - 3. Temperature Coefficient (NOTC Open-Circuit Voltage): -13.34 deg C.
 - 4. Temperature Coefficient (NOTC Short Circuit Current): 1.38 deg C.

2.4 PV SYSTEMS DESCRIPTION

- A. Interactive PV System: Collectors connected in parallel to the electrical utility; and capable of providing power for Project and supplying power to a distributed network.
 - 1. System Components:
 - a. PV modules.
 - b. Array frame.
 - c. Utility-interactive inverter.
 - d. Overcurrent protection, disconnect, and rapid shutdown devices.
 - e. Mounting structure.
 - f. Utility meter.

2.5 MANUFACTURED PV UNITS

- A. Cell Materials: Monocrystalline.
- B. Module Construction:
 - 1. Nominal Size: 39.4 inches (1001 mm) wide by 78.46 inches (1993 mm) long.
 - 2. Weight: 47.6 lb (21.6 kg).
- C. Insulating Substrate Film: polyimide.
- D. Conducting Substrate Film: Rigid.
- E. Encapsulant: Ethyl vinyl acetate.
- F. Front Panel: Fully tempered glass.
- G. Backing Material: Polyester film.
 - 1. Layers: Multi.
 - 2. Color: White.
- H. Bypass Diode Protection: Internal.
- I. Junction Box:
 - 1. Size: 1.56 by 3.96 by 0.52 inch (39.6 by 100.6 by 13.2 mm).
 - 2. Fully potted, vandal resistant.
 - 3. IP Code: IP65.
 - 4. Flammability Test: UL 1703.
- J. Output Cabling:
 - 1. 0.158 inch (4 mm).
 - 2. Quick, multiconnect, polarized connectors.
 - 3. Two-Conductor Harness: No traditional return wire is needed from the end of a row back to the source combiner.
- K. Series Fuse Rating: 15 A.

2.6 PV MODULE FRAMING

- A. PV laminates mounted in anodized extruded-aluminum frames.
 - 1. Entire assembly UL listed for electrical and fire safety, according to UL 1703, and complying with IEC 61215.
 - 2. Frame strength exceeding requirements of certifying agencies in subparagraph above.
 - 3. Finish: Anodized aluminum.
 - a. Alloy and temper recommended by framing manufacturer for strength, corrosion resistance, and application of required finish.
 - b. Color: As indicated by manufacturer's designations.

4. Finish: High-performance organic finish.
 - a. Fluoropolymer Two-Coat System: Manufacturer's standard two-coat, thermocured system consisting of specially formulated inhibitive primer and fluoropolymer color topcoat containing not less than 70 percent PVC resin by weight.
 - b. Color: As indicated by manufacturer's designations.
5. Finish: Baked-enamel finish.
 - a. Color: As indicated by manufacturer's designations.

2.7 PV ARRAY CONSTRUCTION

- A. Framing:
 1. Material: Extruded aluminum.
 2. Maximum System Weight: Less than 4 lb/sq. ft. (19.53 kg/sq. m).
 3. Raceway Cover Plates: Aluminum.

2.8 POWER OPTIMIZER

- A. Power optimizer a DC/DC converter connected to solar modules. Power optimizer shall provide internal current limitation as described in NEC Article 690.8. The unit to provide zero backfeed to the PV source circuit, and zero feedback current to the rest of the string. Power optimizer shall automatically reduce module DC voltage to a safe level per NEC whenever the inverter or grid power is shut down.
- B. Power optimizer electrical characteristics:
 1. Rated input DC power: 730 W.
 2. Maximum input voltage: 125 V.
 3. Maximum short circuit current: 11 A.
 4. Maximum DC input current: 13.75 A.
 5. Maximum output current: 15 A.
 6. Maximum output voltage: 85 V.

2.9 COMBINER DISCONNECT SWITCH

- A. Combiner Box with Integral finger-safe non-fused Disconnect Switch (1000VDC). Provide combiner box(s) complete with circuitry as necessary to protect the equipment including disconnect switch with finger-safe fuse holders having all necessary fusing and other options, as shown on drawings and listed below:
 1. A finger-safe, non-fused disconnect is required and it shall be interlocked to prevent the opening of the cover when the switch is in the ON position. Interlock shall be defeatable for testing purposes. Handle must be lockable in OFF position.
 2. The combiner box shall be arranged to have 4 input circuits with an 80A non-fused disconnect switch rating.
 3. Individual ampere rating of the fuses shall be as indicated on the drawing.
 4. All fuse holders shall be finger-safe and shall have local open-fuse indication.
 5. The enclosure shall be NEMA 3R with seamless door gaskets.
 6. All busing shall be copper.

2.10 INVERTER

- A. Inverter Type: Central.
- B. Control Type: Pulse-width-modulation control.
- C. Control Type: Maximum power point tracker control.
- D. Inverter Electrical Characteristics:
 1. Maximum Recommended PV Input Power: as noted on the Drawings.

2. Maximum Open-Circuit Voltage: 600 V dc.
 3. PV Start Voltage: 400 V dc.
 4. MPPT Voltage Range: 105 V – 132.5 V.
 5. Maximum Input Current: 38 A.
 6. Number of String Inputs: 3.
 7. Nominal Output Voltage: 240 V ac.
 8. Maximum Output Current: 40 A.
 9. CEC Weighted Efficiency: 97 percent.
 10. CEC Night Tare Loss: 4 W.
 11. DC/AC Terminal Range (AWG): 12-6 AWG.
 12. Communications Interface: RS 485, Ethernet, Wireless.
 13. Utility Interface: Utility-interactive inverter.
- E. Operating Conditions:
1. Operating Ambient Temperatures: Minus 40 to plus 140 deg F (minus 40 to plus 60 deg C).
 2. Storage Temperature: Minus 40 to plus 140 deg F (minus 40 to plus 60 deg C).
 3. Relative Humidity: Zero to 95 percent, noncondensing.
- F. Charge controllers shall have the following:
1. Overcurrent protection.
 2. Generator input breaker box.
 3. Automatic transfer relay.
 4. Digital display.
 5. Transformer.
 6. Disconnect switch.
 7. Shunt controller.
 8. Shunt regulator.
 9. Surge overload protection.
 10. Module level monitoring.
- G. On-Board Metering Package
1. Provide with built-in RGM and power consumption monitoring.
 2. Provide split-core CTs rated for the loads to be monitored.
- H. Enclosure:
1. NEMA 250, Type 3R.
 2. Cooling Methods:
 - a. Fan convection cooling.
 3. Protective Functions:
 - a. AC over/undervoltage.
 - b. AC over/underfrequency.
 - c. Ground overcurrent.
 - d. Overtemperature.
 - e. AC and dc overcurrent.
 - f. DC overvoltage.
 - g. ARC fault protection.
 - h. Rapid shut-down.
 4. Standard LCD, four lines, 20 characters, with user display and on/off toggle switch.
- I. Disconnects: Rated for system voltage and conductor.
- J. Regulatory Approvals:
1. IEEE 1547.1.
 2. IEEE 1547.3.
 3. UL 1741.

2.11 SYSTEM OVERCURRENT PROTECTION

- A. Fuses: 350 A.

2.12 MOUNTING STRUCTURES

- A. Roof Mount: Attached to standing seam metal roof with approved fasteners.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrate areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Do not begin installation until mounting surfaces have been properly prepared.
- C. If preparation of mounting surfaces is the responsibility of another installer, notify Architect of unsatisfactory preparation before proceeding.
- D. Examine modules and array frame before installation. Reject modules and arrays that are wet, moisture damaged, or mold damaged.
- E. Examine roofs, supports, and supporting structures for suitable conditions where PV system will be installed.
- F. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Comply with NECA 1.
- B. Coordinate layout and installation of PV panels with roof and support assembly and other construction.
- C. Support PV panel assemblies independent of supports for other elements such as roof and support assemblies, enclosures, vents, pipes, and conduits. Support assembly to prevent twisting from eccentric loading.
- D. Install PV inverters, charge controller, rapid shutdown, and system control in locations indicated on Drawings.
- E. Install weather seal fittings and flanges where PV panel assemblies penetrate exterior elements such as walls or roofs. Seal around openings to make weathertight.
- F. Wiring Method: Install cables in raceways.
- G. 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.
- H. Provide all labels and signage per NFC 690.

3.3 CONNECTIONS

- A. Coordinate PV panel cabling to equipment enclosures to ensure proper connections.
- B. Coordinate installation of utility-interactive meter with utility.
- C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.
- D. 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.
- E. Provide all required wiring between CTs and built-in RGMs.

END OF SECTION 26 31 00

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SECTION 26 32 13 - ENGINE GENERATORS**PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

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

1.2 SUMMARY

- A. This Section includes packaged engine-generator sets for emergency power supply with the following features:
 - 1. Diesel engine.
 - 2. Unit-mounted cooling system.
 - 3. Unit-mounted control and monitoring.
 - 4. Outdoor enclosure.
- B. Related Sections include the following:
 - 1. Division 26 Section "Transfer Switches" for transfer switches including sensors and relays to initiate automatic-starting and -stopping signals for engine-generator sets.
 - 2. Division 26 Section "Seismic Controls for Electrical Systems".
 - 3. **Division 26 Section "Supervisory Control and Data Acquisition Systems Version 1.2" for hardware and installation requirements related to interface of the generator with the SCADA system.**

1.3 DEFINITIONS

- A. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.

1.4 SUBMITTALS

- A. Product Data: For each type of packaged engine generator indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. In addition, include the following:
 - 1. Thermal damage curve for generator.
 - 2. Time-current characteristic curves for generator protective device.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 1. Dimensioned outline plan and elevation drawings of engine-generator set and other components specified.
 - 2. Design Calculations: Signed and sealed by a qualified professional engineer. Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
 - 3. Vibration Isolation Base Details: Signed and sealed by a qualified professional engineer. Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include base weights.
 - 4. Wiring Diagrams: Power, signal, and control wiring.
- C. Qualification Data: For installer.
- D. Source quality-control test reports.
 - 1. Certified summary of prototype-unit test report.

2. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.
3. Certified Summary of Performance Tests: Certify compliance with specified requirement to meet performance criteria for sensitive loads.
4. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.
5. Report of sound generation.
6. Report of exhaust emissions showing compliance with applicable regulations.
7. Certified Torsional Vibration Compatibility: Comply with NFPA 110.
- E. Field quality-control test reports.
- F. Operation and Maintenance Data: For packaged engine generators to include in emergency, operation, and maintenance manuals.
 1. List of tools and replacement items recommended to be stored at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.
- G. Warranty: Special warranty specified in this Section.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
 1. Maintenance Proximity: Not more than four hours' normal travel time from Installer's place of business to Project site.
 2. Engineering Responsibility: Preparation of data for vibration isolators and seismic restraints of engine skid mounts, including Shop Drawings, based on testing and engineering analysis of manufacturer's standard units in assemblies similar to those indicated for this Project.
- B. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 200 miles (321 km) of Project site, a service center capable of providing training, parts, and emergency maintenance repairs.
- C. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL), and that is acceptable to authorities having jurisdiction.
 1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- D. Source Limitations: Obtain packaged generator sets and auxiliary components through one source from a single manufacturer.
- E. 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.
- F. Comply with ASME B15.1.
- G. Comply with NFPA 37.
- H. Comply with NFPA 70.
- I. Comply with NFPA 99.
- J. Comply with NFPA 110 requirements for Level 1 emergency power supply system.
- K. Comply with UL 2200.
- L. Engine Exhaust Emissions: Comply with applicable state and local government requirements.
- M. Noise Emission: Comply with applicable state and local government requirements for maximum noise level at adjacent property boundaries due to sound emitted by generator set including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

1.6 PROJECT CONDITIONS

- A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
 - 1. Notify Designer no fewer than ten (10) days in advance of proposed interruption of electrical service.
 - 2. Do not proceed with interruption of electrical service without Designer's written permission.
- B. Environmental Conditions: Engine-generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:
 - 1. Ambient Temperature: 5 to 40 deg C.
 - 2. Relative Humidity: 0 to 95 percent.
 - 3. Altitude: Sea level to 1000 feet (300 m).

1.7 COORDINATION

- A. Coordinate size and location of concrete bases for package engine generators. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.8 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Five (5) years from date of Final Acceptance.

1.9 MAINTENANCE SERVICE

- A. Initial Maintenance Service: Beginning at Substantial Completion, provide 12 months' full maintenance by skilled employees of manufacturer's designated service organization. Include quarterly exercising to check for proper starting, load transfer, and running under load. Include routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Provide parts and supplies same as those used in the manufacture and installation of original equipment.

1.10 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Fuses: One for every 10 of each type and rating, but no fewer than one of each.
 - 2. Indicator Lamps: Two for every six of each type used, but no fewer than two of each.
 - 3. Filters: One set each of lubricating oil, fuel, and combustion-air filters.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Caterpillar; Engine Div.
2. Kohler Co.; Generator Division.
3. Onan/Cummins Power Generation; Industrial Business Group.

2.2 ENGINE-GENERATOR SET

- A. Factory-assembled and -tested, engine-generator set.
- B. Mounting Frame: Maintain alignment of mounted components without depending on concrete foundation; and have lifting attachments.
 1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and generator-set center of gravity.
- C. Capacities and Characteristics:
 1. Power Output Ratings: Nominal ratings as indicated, with capacity as required to operate as a unit as evidenced by records of prototype testing.
 2. Output Connections: Three-phase, four wire.
 3. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.
- D. Generator-Set Performance:
 1. Steady-State Voltage Operational Bandwidth: 3 percent of rated output voltage from no load to full load.
 2. Transient Voltage Performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within three seconds.
 3. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency from no load to full load.
 4. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
 5. Transient Frequency Performance: Less than 5 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds.
 6. Output Waveform: At no load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for single harmonics. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
 7. Sustained Short-Circuit Current: For a 3-phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.
 8. Start Time: Comply with NFPA 110, Type 10, system requirements.
- E. Generator-Set Performance for Sensitive Loads:
 1. Oversizing generator compared with the rated power output of the engine is permissible to meet specified performance.
 - a. Nameplate Data for Oversized Generator: Show ratings required by the Contract Documents rather than ratings that would normally be applied to generator size installed.
 2. Steady-State Voltage Operational Bandwidth: 1 percent of rated output voltage from no load to full load.
 3. Transient Voltage Performance: Not more than 10 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within 0.5 second.
 4. Steady-State Frequency Operational Bandwidth: Plus or minus 0.25 percent of rated frequency from no load to full load.

5. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
6. Transient Frequency Performance: Less than 2-Hz variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within three seconds.
7. Output Waveform: At no load, harmonic content measured line to neutral shall not exceed 2 percent total with no slot ripple. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
8. Sustained Short-Circuit Current: For a 3-phase, bolted short circuit at system output terminals, system shall supply a minimum of 300 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to winding insulation or other generator system components.
9. Excitation System: Performance shall be unaffected by voltage distortion caused by nonlinear load.
 - a. Provide permanent magnet excitation for power source to voltage regulator.
10. Start Time: Comply with NFPA 110, Type 10, system requirements.

2.3 ENGINE

- A. Fuel: Fuel oil, Grade DF-2.
- B. Rated Engine Speed: 1800 rpm.
- C. Maximum Piston Speed for Four-Cycle Engines: 2250 fpm (11.4 m/s).
- D. Lubrication System: The following items are mounted on engine or skid:
 1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
 2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
 3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.
- E. Engine Fuel System:
 1. Main Fuel Pump: Mounted on engine. Pump ensures adequate primary fuel flow under starting and load conditions.
 2. Relief-Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.
- F. Coolant Jacket Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity.
- G. Governor: Adjustable isochronous, with speed sensing.
- H. Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine-generator-set mounting frame and integral engine-driven coolant pump.
 1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
 2. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
 3. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.
 4. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
 5. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, ultraviolet-, and abrasion-resistant fabric.

- a. Rating: 50-psig (345-kPa) maximum working pressure with coolant at 180 deg F (82 deg C), and noncollapsible under vacuum.
 - b. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.
- I. Muffler/Silencer: Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
 - 1. Minimum sound attenuation of 25 dB at 500 Hz.
 - 2. Sound level measured at a distance of 10 feet (3 m) from exhaust discharge after installation is complete shall be 85 dBA or less.
- J. Air-Intake Filter: Heavy-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.
- K. Starting System: 24-V electric, with negative ground.
 - 1. Components: Sized so they will not be damaged during a full engine-cranking cycle with ambient temperature at maximum specified in Part 1 "Project Conditions" Article.
 - 2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
 - 3. Cranking Cycle: As required by NFPA 110 for system level specified.
 - 4. Battery: Adequate capacity within ambient temperature range specified in Part 1 "Project Conditions" Article to provide specified cranking cycle at least three times without recharging.
 - 5. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
 - 6. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 10 deg C regardless of external ambient temperature within range specified in Part 1 "Project Conditions" Article. Include accessories required to support and fasten batteries in place.
 - 7. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.
 - 8. Battery Charger: Current-limiting, automatic-equalizing and float-charging type. Unit shall comply with UL 1236 and include the following features:
 - a. Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
 - b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 deg C to plus 60 deg C to prevent overcharging at high temperatures and undercharging at low temperatures.
 - c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
 - d. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.
 - e. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
 - f. Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.

2.4 FUEL OIL STORAGE

- A. Comply with NFPA 30.
- B. Base-Mounted Fuel Oil Tank: Factory installed and piped, complying with UL 142 fuel oil tank. Features include the following:
 - 1. Tank level indicator.
 - 2. **Capacity: Fuel for 72 hours' continuous operation at 100 percent rated power output.**
 - 3. Vandal-resistant fill cap.
 - 4. Containment Provisions: Comply with requirements of authorities having jurisdiction.

2.5 CONTROL AND MONITORING

- A. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of generator set. When mode-selector switch is switched to the on position, generator set starts. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms. Operation of a remote emergency-stop switch also shuts down generator set.
- B. Manual Starting System Sequence of Operation: Switching on-off switch on the generator control panel to the on position starts generator set. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms. Operation of a remote emergency-stop switch also shuts down generator set.
- C. Configuration: Operating and safety indications, protective devices, basic system controls, engine gages, instrument transformers, generator disconnect switch or circuit breaker, and other indicated components shall be grouped in a combination control and power panel. Control and monitoring section of panel shall be isolated from power sections by steel barriers. Panel features shall include the following:
 - 1. Wall-Mounting Cabinet Construction: Rigid, self-supporting steel unit complying with NEMA ICS 6. Power bus shall be copper. Bus, bus supports, control wiring, and temperature rise shall comply with UL 891.
 - 2. Current and Potential Transformers: Instrument accuracy class.
- D. Indicating and Protective Devices and Controls: As required by NFPA 110 for Level 1 system, and the following:
 - 1. AC voltmeter.
 - 2. AC ammeter.
 - 3. AC frequency meter.
 - 4. DC voltmeter (alternator battery charging).
 - 5. Engine-coolant temperature gage.
 - 6. Engine lubricating-oil pressure gage.
 - 7. Running-time meter.
 - 8. Ammeter-voltmeter, phase-selector switch(es).
 - 9. Generator-voltage adjusting rheostat.
 - 10. Fuel tank derangement alarm.
 - 11. Fuel tank high-level shutdown of fuel supply alarm.
 - 12. Generator overload.
- E. Indicating and Protective Devices and Controls:
 - 1. AC voltmeter.
 - 2. AC ammeter.
 - 3. AC frequency meter.
 - 4. DC voltmeter (alternator battery charging).
 - 5. Engine-coolant temperature gage.

6. Engine lubricating-oil pressure gage.
 7. Running-time meter.
 8. Ammeter-voltmeter, phase-selector switch(es).
 9. Generator-voltage adjusting rheostat.
 10. Start-stop switch.
 11. Overspeed shutdown device.
 12. Coolant high-temperature shutdown device.
 13. Coolant low-level shutdown device.
 14. Oil low-pressure shutdown device.
 15. Fuel tank derangement alarm.
 16. Fuel tank high-level shutdown of fuel supply alarm.
 17. Generator overload.
- F. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator, unless otherwise indicated.

2.6 GENERATOR OVERCURRENT AND FAULT PROTECTION

- A. Generator Circuit Breaker: Molded case type; 80 percent rated; complying with UL 489. Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.
1. Trip Settings: Selected to coordinate with generator thermal damage curve.
 2. Shunt Trip: Connected to trip breaker when generator set is shut down by other protective devices.
 3. Mounting: Adjacent to or integrated with control and monitoring panel.
- B. Generator Protector: Microprocessor-based unit shall continuously monitor current level in each phase of generator output, integrate generator heating effect over time, and predict when thermal damage of alternator will occur. When signaled by generator protector or other generator-set protective devices, a shunt-trip device in the generator disconnect switch shall open the switch to disconnect the generator from load circuits. Protector shall perform the following functions:
1. Initiates a generator overload alarm when generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other generator-set malfunction alarms.
 2. Under single or three-phase fault conditions, regulates generator to 300 percent of rated full-load current for up to 10 seconds.
 3. As overcurrent heating effect on the generator approaches the thermal damage point of the unit, protector switches the excitation system off, opens the generator disconnect device, and shuts down the generator set.
 4. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot.

2.7 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

- A. Comply with NEMA MG 1.
- B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.
- C. Electrical Insulation: Class H or Class F.
- D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required.
- E. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.
- F. Enclosure: Dripproof.
- G. Instrument Transformers: Mounted within generator enclosure.
- H. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified.

1. Adjusting rheostat on control and monitoring panel shall provide plus or minus 5 percent adjustment of output-voltage operating band.
- I. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.
- J. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.
- K. Subtransient Reactance: 12 percent, maximum.

2.8 OUTDOOR GENERATOR-SET ENCLOSURE

- A. Description: Vandal-resistant, weatherproof steel housing, wind resistant up to 100 mph (160 km/h). Multiple panels shall be lockable and provide adequate access to components requiring maintenance. Panels shall be removable by one person without tools. Instruments and control shall be mounted within enclosure.
- B. Description: Prefabricated or pre-engineered enclosure with the following features:
 1. Construction: Galvanized-steel, metal-clad, integral structural-steel-framed building erected on concrete foundation.
 2. Structural Design and Anchorage: Comply with ASCE 7 for wind loads and seismic loads.
 3. Space Heater: Thermostatically controlled and sized to prevent condensation.
 4. Louvers: Equipped with bird screen and filter arranged to permit air circulation when engine is not running while excluding exterior dust, birds, and rodents.
 5. Hinged Doors: With padlocking provisions. **Provide magnetic switches at each door with form C contacts for integration into SCADA systems.**
 6. Ventilation: Louvers equipped with bird screen and filter arranged to permit air circulation while excluding exterior dust, birds, and rodents.
 7. Thermal Insulation: Manufacturer's standard materials and thickness selected in coordination with space heater to maintain winter interior temperature within operating limits required by engine-generator-set components.
 8. Muffler Location: External to enclosure.
- C. Engine Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at 110 percent of rated load for 2 hours with ambient temperature at top of range specified in system service conditions.
 1. Louvers: Fixed-engine, cooling-air inlet and discharge. Storm-proof and drainable louvers prevent entry of rain and snow.
 2. Automatic Dampers: At engine cooling-air inlet and discharge. Dampers shall be closed to reduce enclosure heat loss in cold weather when unit is not operating.

2.9 VIBRATION ISOLATION DEVICES

- A. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic restraint.
 1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to wind loads or if weight is removed; factory-drilled baseplate bonded to 1/4-inch- (6-mm-) thick, elastomeric isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
 2. Outside Spring Diameter: Not less than 80 percent of compressed height of the spring at rated load.
 3. Minimum Additional Travel: 50 percent of required deflection at rated load.
 4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.10 FINISHES

- A. Indoor and Outdoor Enclosures and Components: Manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer.

2.11 SOURCE QUALITY CONTROL

- A. Prototype Testing: Factory test engine-generator set using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.
 - 1. Tests: Comply with NFPA 110, Level 1 Energy Converters and with IEEE 115.
- B. Project-Specific Equipment Tests: Before shipment, factory test engine-generator set and other system components and accessories manufactured specifically for this Project. Perform tests at rated load and power factor. Include the following tests:
 - 1. Test components and accessories furnished with installed unit that are not identical to those on tested prototype to demonstrate compatibility and reliability.
 - 2. Full load run.
 - 3. Maximum power.
 - 4. Voltage regulation.
 - 5. Transient and steady-state governing.
 - 6. Single-step load pickup.
 - 7. Safety shutdown.
 - 8. Provide 14 days' advance notice of tests and opportunity for observation of tests by Owner's representative.
 - 9. Report factory test results within 10 days of completion of test.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine-generator performance.
- B. Examine roughing-in of piping systems and electrical connections. Verify actual locations of connections before packaged engine-generator installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Comply with packaged engine-generator manufacturers' written installation and alignment instructions and with NFPA 110.
- B. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance. Should the access height of any electrical components above finished grade be greater than that required by Code, the manufacturer shall provide pre-manufactured aluminum stairs and platforms.
- C. Install packaged engine generator with restrained spring isolators having a minimum deflection of 1 inch (25 mm) on 4-inch- (100-mm-) high concrete base.
- D. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

3.3 CONNECTIONS

- A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

- B. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- C. **Connect SCADA system components according to Division 26 Section "Supervisory Control and Data Acquisition Systems".**

3.4 IDENTIFICATION

- A. Identify system components according to Division 26 Section "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
- B. Perform tests and inspections and prepare test reports.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- C. Tests and Inspections:
 - 1. Perform tests recommended by manufacturer and each electrical test and visual and mechanical inspection for "AC Generators and for Emergency Systems" specified in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 2. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here including, but not limited to, single-step full-load pickup test.
 - 3. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.
 - a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
 - b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
 - c. Verify acceptance of charge for each element of the battery after discharge.
 - d. Verify that measurements are within manufacturer's specifications.
 - 4. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
 - 5. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine-generator system before and during system operation. Check for air, exhaust, and fluid leaks.
 - 6. Exhaust-System Back-Pressure Test: Use a manometer with a scale exceeding 40-inch wg (120 kPa). Connect to exhaust line close to engine exhaust manifold. Verify that back pressure at full-rated load is within manufacturer's written allowable limits for the engine.
 - 7. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.
 - 8. Harmonic-Content Tests: Measure harmonic content of output voltage under 25 percent and at 100 percent of rated linear load. Verify that harmonic content is within specified limits.
- D. Coordinate tests with tests for transfer switches and run them concurrently.
- E. Test instruments shall have been calibrated within the last 12 months, traceable to standards of NIST, and adequate for making positive observation of test results. Make calibration records available for examination on request.

- F. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
- G. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
- H. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- I. Remove and replace malfunctioning units and retest as specified above.
- J. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.
- K. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.
- L. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each power wiring termination and each bus connection. Remove all access panels so terminations and connections are accessible to portable scanner.
 - 1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan 11 months after date of Substantial Completion.
 - 2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - 3. Record of Infrared Scanning: Prepare a certified report that identifies terminations and connections checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
- M. Contractor shall fuel the generator after all testing has been completed and project has been accepted by the Designer and the Owner. Contractor shall provide full tank of fuel.

3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators.

END OF SECTION 26 32 13

SECTION 26 36 00 - TRANSFER SWITCHES**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.
- B. Section 260548 - Seismic Controls for Electrical Systems
- C. Section 263213 - Engine Generators
- D. **Special attention shall be paid to Section 26999-SCADA Systems. Coordinate the requirements of this section with that section for any necessary options necessary to interface with the SCADA.**

1.2 SUMMARY

- A. This Section includes transfer switches rated 600 V and less, including the following:
 - 1. Automatic transfer switch.

1.3 SUBMITTALS

- A. Product Data: Include ratings and dimensioned plans, sections, and elevations showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists for each switch specified.
- B. Wiring Diagrams: Detail wiring for transfer switches and differentiate between manufacturer-installed and field-installed wiring. Show both power and control wiring.
- C. Single-Line Diagram: Show connections between transfer switch, bypass/isolation switch, power sources, and load; and show interlocking provisions for each combined transfer switch and bypass/isolation switch.
- D. Product Certificates: Signed by manufacturer certifying that products furnished comply with requirements and that switches have been tested for load ratings and short-circuit closing and withstand ratings applicable to units for Project.
- E. Qualification Data: For firms and persons specified in "Quality Assurance" Article.
- F. Field Test Reports: Indicate and interpret test and inspection results for compliance with performance requirements.
- G. Maintenance Data: For each type of product to include in maintenance manuals specified in Division 1. Include all features and operating sequences, both automatic and manual. List all factory settings of relays and provide relay-setting and calibration instructions, including software, where applicable.

1.4 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Maintain a service center capable of providing emergency maintenance and repairs at Project site with an eight-hour maximum response time.
- B. Source Limitations: Obtain automatic transfer switch, bypass/isolation switch, nonautomatic transfer switch, remote annunciators, and remote annunciator and control panels through one source from a single manufacturer.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, for emergency service under UL 1008, by a testing agency acceptable to authorities having jurisdiction.
- D. Comply with NEMA ICS 1.
- E. Comply with NFPA 70.
- F. Comply with NFPA 99.
- G. Comply with NFPA 110.
- H. Comply with UL 1008, unless requirements of these Specifications are stricter.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Transfer Switches Using Molded-Case Switches or Circuit Breakers:
 - a. Eaton Corp.; Westinghouse & Cutler-Hammer Products.
 - b. Zenith
 - c. ASCO

2.2 GENERAL TRANSFER-SWITCH PRODUCT REQUIREMENTS

- A. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.
- B. Tested Fault-Current Closing and Withstand Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.
 - 1. Where Transfer Switch Includes Internal Fault-Current Protection: Rating of switch and trip unit combination exceeds indicated fault-current value at installation location.
- C. Annunciation, Control, and Programming Interface Components: Devices at transfer switches for communicating with remote programming devices, annunciators, or annunciator and control panels have communications capability matched with remote device.
- D. Solid-State Controls: Repetitive accuracy of all settings is plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.
- E. Resistance to Damage by Voltage Transients: Components meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.41. Components meet or exceed voltage-impulse withstand test of NEMA ICS 1.
- F. Neutral Terminal: Solid and fully rated, for those switches designated as solely 3-pole. Where four-pole switches are indicated, provide neutral pole switched simultaneously with phase poles.
- G. Enclosures: **NEMA 1**, complying with NEMA ICS 6; UL 508, unless otherwise indicated.
- H. Factory Wiring: Train and bundle factory wiring and label consistent with Shop Drawings, either by color code or by numbered or lettered wire and cable tape markers at terminations.
 - 1. Designated Terminals: Pressure type suitable for types and sizes of field wiring indicated.
 - 2. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
 - 3. Control Wiring: Equipped with lugs suitable for connection to terminal strips.
- I. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism, mechanically and electrically interlocked in both directions.
- J. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.
 - 1. Switch Action: Double throw; mechanically held in both directions.
 - 2. Contacts: Silver composition or silver alloy for load-current switching. Conventional automatic transfer-switch units rated 225 A and greater have separate arcing contacts.

2.3 AUTOMATIC TRANSFER SWITCHES

- A. Comply with Level 1 equipment according to NFPA 110.
- B. Switching Arrangement: Double-throw type, incapable of pauses or intermediate position stops during normal functioning, unless otherwise indicated.
- C. Manual Switch Operation: Under load, with door closed and with either or both sources energized. Transfer time is the same as for electrical operation. Control circuit automatically disconnects from electrical operator during manual operation.
- D. Signal-before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval is adjustable from 1 to 30 seconds.
- E. Digital Communications Interface: Matched to capability of remote annunciator or annunciator and control panel.
- F. Transfer Switches Based on Molded-Case-Switch Components: Comply with NEMA AB 1, UL 489, and UL 869A.

2.4 AUTOMATIC TRANSFER-SWITCH FEATURES

- A. Time delay for override of normal-source voltage sensing delays transfer and engine start signals. Adjustable from zero to six seconds, and factory set for one second.
- B. Undervoltage Sensing for Each Phase of Normal Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage is adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
- C. Voltage/Frequency Lockout Relay: Prevents premature transfer to generator set. Pickup voltage is adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency is adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.
- D. Time Delay for Retransfer to Normal Source: Adjustable from 0 to 30 minutes; factory set for 10 minutes. Provides automatic defeat of delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
- E. Test Switch: Simulates normal-source failure.
- F. Switch-Position Pilot Lights: Indicate source to which load is connected.
- G. Source-Available Indicating Lights: Supervise sources via transfer-switch, normal- and emergency-source sensing circuits.
 - 1. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
 - 2. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."
- H. Unassigned Auxiliary Contacts: Two normally open single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.
- I. Timed auxiliary contacts for connection to elevator controls.
- J. Transfer Override Switch: Overrides automatic retransfer control so automatic transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.
- K. Engine Starting Contacts: One isolated, normally closed and one isolated, normally open, rated 10 A at 32-V dc minimum.
- L. Engine Shutdown Contacts: Time delay adjustable from zero to five minutes; factory set for five minutes. Initiates shutdown at remote engine-generator controls after retransfer of load to normal source.
- M. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine-generator set and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods are adjustable from 10 to 30 minutes. Factory settings are for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:

1. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
2. Push-button programming control with digital display of settings.
3. Integral battery operation of time switch when normal control power is not available.

2.5 FINISHES

- A. Enclosures: Manufacturer's standard enamel over corrosion-resistant pretreatment and primer.

2.6 SOURCE QUALITY CONTROL

- A. Factory Test Components, Assembled Switches, and Associated Equipment: Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Four-Pole Switches: Where four-pole switches are indicated, install neutral switching.

3.2 INSTALLATION

- A. Floor-Mounted Switch: Level and anchor unit to floor.
- B. Identify components according to Division 26 Section "Electrical General Provisions."
- C. Identify components according to Division 26 Section "Equipment Identification."

3.3 WIRING TO REMOTE COMPONENTS

- A. Match type and number of cables and conductors to control and communications requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner if necessary to accommodate required wiring.

3.4 CONNECTIONS

- A. Ground equipment as indicated and as required by NFPA 70.

3.5 FIELD QUALITY CONTROL

- A. Testing: Perform the following field quality-control testing under the supervision of the manufacturer's factory-authorized service representative in addition to tests recommended by the manufacturer:
 1. Before energizing equipment, after transfer-switch products have been installed:
 - a. Measure insulation resistance phase-to phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Meet manufacturer's specified minimum resistance.
 - b. Check for electrical continuity of circuits and for short circuits.
 - c. Inspect for physical damage; proper installation and connection; and integrity of barriers, covers, and safety features.
 - d. Verify that manual transfer warnings are properly placed.
 - e. Perform manual transfer operation.

2. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.
 - a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
 - b. Simulate loss of phase-to-ground voltage for each phase of normal source.
 - c. Verify time-delay settings.
 - d. Verify pickup and dropout voltages by data readout or inspection of control settings.
 - e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
 - f. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for one pole deviating by more than 50 percent from other poles.
 - g. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown sequence.
- B. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.
 1. Assist in verifying grounding connections and locations and ratings of sensors.
 2. Assist in observing reaction of circuit-interrupting devices when simulated fault current is applied at sensors.
- C. Coordinate tests with tests of generator plant and run them concurrently.
- D. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.

3.6 CLEANING

- A. After completing equipment installation, inspect unit components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.
- B. Clean equipment internally, on completion of installation, according to manufacturer's written instructions.

3.7 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's personnel to adjust, operate, and maintain transfer switches and related equipment as specified below:
 1. Coordinate this training with that for generator equipment.
 2. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment.
 3. Review data in maintenance manuals. Refer to Division 1.
 4. Schedule training with Owner, through Architect, with at least seven days' advance notice.
 5. Provide a minimum of four hours of instruction.

END OF SECTION 26 36 00

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SECTION 26 43 13 - TRANSIENT-VOLTAGE SUPPRESSION 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. This Section includes TVSSs for low-voltage power, control, and communication equipment.

1.3 DEFINITIONS

- A. ATS: Acceptance Testing Specifications.
- B. SVR: Suppressed voltage rating.
- C. TVSS: Transient voltage surge suppressor.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating weights, operating characteristics, furnished specialties, and accessories.
- B. Product Certificates: For transient voltage suppression devices, signed by product manufacturer certifying compliance with the following standards:
 - 1. UL 1283.
 - 2. UL 1449.
- C. Qualification Data: For testing agency.
- D. Field quality-control test reports, including the following:
- E. Test procedures used.
- F. Test results that comply with requirements.
- G. Failed test results and corrective action taken to achieve requirements.
- H. Operation and Maintenance Data: For transient voltage suppression devices to include in emergency, operation, and maintenance manuals.
- I. Warranties: Special warranties specified in this Section.

1.5 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
 - 1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- B. Source Limitations: Obtain suppression devices and accessories through one source from a single manufacturer.
- C. Product Options: Drawings indicate size, dimensional requirements, and electrical performance of suppressors and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- E. Comply with IEEE C62.41, "IEEE Guide for Surge Voltages in Low Voltage AC Power Circuits," and test devices according to IEEE C62.45, "IEEE Guide on Surge Testing for Equipment Connected to Low-Voltage AC Power Circuits."
- F. Comply with NEMA LS 1, "Low Voltage Surge Protection Devices."
- G. Comply with UL 1283, "Electromagnetic Interference Filters," and UL 1449, "Transient Voltage Surge Suppressors."

1.6 PROJECT CONDITIONS

- A. Service Conditions: Rate surge protection devices for continuous operation under the following conditions, unless otherwise indicated:
 - 1. Maximum Continuous Operating Voltage: Not less than 115 percent of nominal system operating voltage.
 - 2. Operating Temperature: 30 to 120 deg F (0 to 50 deg C).
 - 3. Humidity: 0 to 85 percent, noncondensing.
 - 4. Altitude: Less than 20,000 feet (6090 m) above sea level.

1.7 COORDINATION

- A. Coordinate location of field-mounted surge suppressors to allow adequate clearances for maintenance.

1.8 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of surge suppressors that fail in materials or workmanship within five years from date of Substantial Completion.

1.9 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Replaceable Protection Modules: One of each size and type installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Advanced Protection Technologies, Inc.
 - 2. Current Technology, Inc.
 - 3. Cutler-Hammer, Inc.; Eaton Corporation.
 - 4. General Electric Company.
 - 5. Innovative Technology, Inc.
 - 6. Leviton Mfg. Company Inc.
 - 7. Siemens Energy & Automation, Inc.
 - 8. Square D; Schneider Electric.
 - 9. Surge Suppression Incorporated.
 - 10. Tycor; Cutler-Hammer, Inc.

11. United Power Corporation.

2.2 SERVICE ENTRANCE SUPPRESSORS

- A. Surge Protection Device Description: Modular design with field-replaceable modules, sine-wave-tracking type with the following features and accessories:
 1. Fuses, rated at 200-kA interrupting capacity.
 2. Fabrication using bolted compression lugs for internal wiring.
 3. Integral disconnect switch.
 4. Redundant suppression circuits.
 5. Redundant replaceable modules.
 6. Arrangement with copper bus bars and for bolted connections to phase buses, neutral bus, and ground bus.
 7. Arrangement with wire connections to phase buses, neutral bus, and ground bus.
 8. LED indicator lights for power and protection status.
 9. Audible alarm, with silencing switch, to indicate when protection has failed.
 10. One set of dry contacts rated at 5 A and 250-V ac, for remote monitoring of protection status. Coordinate with building power monitoring and control system.
 11. Surge-event operations counter.
- B. Peak Single-Impulse Surge Current Rating: 320 kA per phase.
- C. Connection Means: Permanently wired.
- D. Protection modes and UL 1449 SVR for grounded wye circuits with voltages of 208Y/120, 3-phase, 4-wire circuits shall be as follows:
 1. Line to Neutral: 400 V for 208Y/120.
 2. Line to Ground: 400 V for 208Y/120.
 3. Neutral to Ground: 400 V for 208Y/120.

2.3 ENCLOSURES

- A. NEMA 250, with type matching the enclosure of panel or device being protected.

PART 3 - EXECUTION

3.1 INSTALLATION OF SURGE PROTECTION DEVICES

- A. Install devices at service entrance on load side, with ground lead bonded to service entrance ground.
- B. Install devices for panelboard and auxiliary panels with conductors or buses between suppressor and points of attachment as short and straight as possible. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.
 1. Provide multipole, 60-A circuit breaker as a dedicated disconnect for suppressor, unless otherwise indicated.

3.2 PLACING SYSTEM INTO SERVICE

- A. Do not energize or connect service entrance equipment to their sources until surge protection devices are installed and connected.

3.3 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust equipment installation, including connections, and to assist in field testing. Report results in writing.
 1. Verify that electrical wiring installation complies with manufacturer's written installation requirements.

- B. Testing: Perform the following field tests and inspections and prepare test reports:
 - 1. After installing surge protection devices, but before electrical circuitry has been energized, test for compliance with requirements.
 - 2. Complete startup checks according to manufacturer's written instructions.
 - 3. Perform each visual and mechanical inspection and electrical test stated in NETA ATS, "Surge Arresters, Low-Voltage Surge Protection Devices" Section. Certify compliance with test parameters.
- C. Remove and replace malfunctioning units and retest as specified above.

3.4 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain transient voltage suppression devices. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 26 43 13

SECTION 26 51 00 - 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. This Section includes the following:
 - 1. Interior lighting fixtures, lamps, and ballasts.
 - 2. Emergency lighting units.
 - 3. Exit signs.
 - 4. Lighting fixture supports.

1.3 DEFINITIONS

- A. BF: Ballast factor.
- B. CRI: Color-rendering index.
- C. CU: Coefficient of utilization.
- D. HID: High-intensity discharge.
- E. LER: Luminaire efficacy rating.
- F. Luminaire: Complete lighting fixture, including ballast housing if provided.
- G. RCR: Room cavity ratio.

1.4 SUBMITTALS

- A. Product Data: For each type of lighting fixture, arranged in order of fixture designation. Include data on features, accessories, finishes, and the following:
 - 1. Physical description of lighting fixture including dimensions.
 - 2. Emergency lighting units including battery and charger.
 - 3. Ballast.
 - 4. Energy-efficiency data.
 - 5. Life, output, and energy-efficiency data for lamps.
 - 6. Photometric data, in IESNA format, based on laboratory tests of each lighting fixture type, outfitted with lamps, ballasts, and accessories identical to those indicated for the lighting fixture as applied in this Project.
 - a. Photometric data shall be certified by a manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program (NVLAP) for Energy Efficient Lighting Products.
- B. Shop Drawings: Show details of nonstandard or custom lighting fixtures. Indicate dimensions, weights, methods of field assembly, components, features, and accessories.
 - 1. Wiring Diagrams: Power wiring.
- C. Samples for Verification: Interior lighting fixtures designated for sample submission in Interior Lighting Fixture Schedule. Each sample shall include the following:
 - 1. Lamps: Specified units installed.
 - 2. Accessories: Cords and plugs.
- D. Product Certificates: For each type of ballast for bi-level and dimmer-controlled fixtures, signed by product manufacturer.
- E. Qualification Data: For agencies providing photometric data for lighting fixtures.
- F. Field quality-control test reports.
- G. Operation and Maintenance Data: For lighting equipment and fixtures to include in emergency, operation, and maintenance manuals.

- H. Warranties: Special warranties specified in this Section.

1.5 QUALITY ASSURANCE

- A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by manufacturers' laboratories that are accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.
- B. 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.
- C. Comply with NFPA 70.

1.6 COORDINATION

- A. Coordinate layout and installation of lighting fixtures and suspension system with other construction that penetrates ceilings or is supported by them, including HVAC equipment, fire-suppression system, and partition assemblies.

1.7 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace products 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 specified warranty period. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, or unauthorized repairs or alterations from special warranty coverage.
1. Warranty Period for Luminaires: Five years from date of Substantial Completion.
 2. Warranty Period for Metal Corrosion: Five years from date of Substantial Completion.
 3. Warranty Period for Color Retention: Five years from date of Substantial Completion.
 4. LED Luminaire Warranty:
 - a. Provide a comprehensive written 5-year warranty for including luminaire finish, on-site replacement of material, and workmanship. On-site replacement includes transportation, removal, and installation of new products. Finish warranty shall include warranty against failure or substantial deterioration such as blistering, cracking, peeling, chalking, or fading.
 - b. Provide a written 5-year replacement material warranty for defective or non-starting LED source assemblies.
 - c. Provide a written 5-year replacement material warranty on all PSUs.
 - d. Provide a written 5-year replacement warranty for non-maintained illuminance levels on all light sources (LED package, LED array, or LED module) including, but not limited to the LED die, encapsulate, and phosphor. If the expected useful life of the luminaire system as defined in this specification is not maintained, then the manufacturer shall replace the light source(s) or luminaire as needed.
 - e. Provide a written 5-year warranty that LED color shift from initial shall color be less than 0.007 on the CIE 1976 (u',v') diagram

1.8 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. LED Modules: 5 for every 100 of each type and rating installed. Furnish at least five (5) of each type.

2. Drivers: 5 for every 100 of each type and rating installed. Furnish at least five (5) of each type.
3. Fixture Types: one (1) of each type.

PART 2 - PRODUCTS

2.1 LIGHTING FIXTURES AND COMPONENTS, GENERAL REQUIREMENTS

- A. Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.
- B. Fluorescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5 and NEMA LE 5A as applicable.
- C. Metal Parts: Free of burrs and sharp corners and edges.
- D. Sheet Metal Components: Steel, unless otherwise indicated. Form and support to prevent warping and sagging.
- E. 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.
- 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.
 4. Laminated Silver Metallized Film: 90 percent.
- G. Plastic Diffusers, Covers, and Globes:
 1. Acrylic Lighting Diffusers: 100 percent virgin acrylic plastic. High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
 - a. Lens Thickness: At least 0.125 inch (3.175 mm) minimum unless different thickness is indicated.
 - b. UV stabilized.
 2. Glass: Annealed crystal glass, unless otherwise indicated.

2.2 LED LIGHTING

- A. General:
 1. LED light fixtures shall be in accordance with IES, NFPA, UL, as shown on the drawings, and as specified.
 2. LED light fixtures shall be Reduction of Hazardous Substances (RoHS)-compliant.
 3. LED drivers shall include the following features unless otherwise indicated:
 - a. Minimum efficiency: 85% at full load.
 - b. Minimum Operating Ambient Temperature: -20° C. (-4° F.)
 - c. Input Voltage: 120 - 277V (±10%) at 60 Hz.
 - d. Integral short circuit, open circuit, and overload protection.
 - e. Power Factor: ≥ 0.95.
 - f. Total Harmonic Distortion: ≤ 20%.
 - g. Comply with FCC 47 CFR Part 15.
 4. LED modules shall include the following features unless otherwise indicated:
 - a. Comply with IES LM-79 and LM-80 requirements.
 - b. Minimum CRI 80 and color temperature 3000° K unless otherwise specified in LIGHTING FIXTURE SCHEDULE.
 - c. Minimum Rated Life: 50,000 hours per IES L70.

- d. Light output lumens as indicated in the LIGHTING FIXTURE SCHEDULE.
- B. LED Downlights:
 - 1. Housing, LED driver, and LED module shall be products of the same manufacturer.

2.3 EXIT SIGNS

- A. Description: 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, 70,000 hours minimum rated lamp life.
 - 2. Self-Powered Exit Signs (Battery Type): Integral automatic charger in a self-contained power pack.
 - a. Battery: Sealed, maintenance-free, nickel-cadmium type.
 - b. Charger: Fully automatic, solid-state type with sealed transfer relay.
 - c. Operation: Relay automatically energizes lamp from battery when circuit voltage drops to 80 percent of nominal voltage or below. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
 - d. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
 - e. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
 - f. Remote Test: Switch in hand-held 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.
 - g. 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 flashing red LED.

2.4 EMERGENCY LIGHTING UNITS

- A. Description: Self-contained units complying with UL 924.
 - 1. Battery: Sealed, maintenance-free, lead-acid type.
 - 2. Charger: Fully automatic, solid-state type with sealed transfer relay.
 - 3. 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.
 - 4. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
 - 5. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
 - 6. Wire Guard: Heavy-chrome-plated wire guard protects lamp heads or fixtures.
 - 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 flashing red LED.

2.5 LIGHTING FIXTURE SUPPORT COMPONENTS

- A. Comply with Division 26 Section "Hangers and Supports for Electrical Systems" and Division 26 Section "Seismic Controls for Electrical Systems" for channel- and angle-iron supports and nonmetallic channel and angle supports.
- B. Single-Stem Hangers: 1/2-inch (13-mm) steel tubing with swivel ball fittings and ceiling canopy. Finish same as fixture.
- C. Twin-Stem Hangers: Two, 1/2-inch (13-mm) steel tubes with single canopy designed to mount a single fixture. Finish same as fixture.
- D. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage (2.68 mm).
- E. Rod Hangers: 3/16-inch (5-mm) minimum diameter, cadmium-plated, threaded steel rod.
- F. Hook Hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Lighting fixtures: Set level, plumb, and square with ceilings and walls. Install lamps in each fixture.
- B. Support for Lighting Fixtures in or on Grid-Type Suspended Ceilings: Use grid as a support element.
 - 1. Install a minimum of four ceiling support system rods or wires for each fixture. Locate not more than 6 inches (150 mm) from lighting fixture corners.
 - 2. Support Clips: Fasten to lighting fixtures and to ceiling grid members at or near each fixture corner with clips that are UL listed for the application.
 - 3. Fixtures of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently with at least two 3/4-inch (20-mm) metal channels spanning and secured to ceiling tees.
 - 4. Install at least one independent support rod or wire from structure to a tab on lighting fixture. Wire or rod shall have breaking strength of the weight of fixture at a safety factor of 3.
- C. Suspended Lighting Fixture Support:
 - 1. Pendants and Rods: Where longer than 48 inches (1200 mm), brace to limit swinging.
 - 2. Stem-Mounted, Single-Unit Fixtures: Suspend with twin-stem hangers.
 - 3. Continuous Rows: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of fixture chassis, including one at each end.
- D. Adjust aimable lighting fixtures to provide required light intensities.
- E. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.2 FIELD QUALITY CONTROL

- A. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery and retransfer to normal.
- B. 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.

END OF SECTION 26 51 00

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SECTION 26 99 99 – SUPERVISORY CONTROL AND DATA ACQUISITION 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 SECTION INCLUDES

- A. MOSCAD Remote Terminal Unit (RTU) equipment.
- B. DEMARC equipment.
- C. Input/Output Sensors.

1.3 SUMMARY

- A. This Section includes equipment for monitoring and controlling remote systems and components, including generators, lift stations and pumping stations.

1.4 SYSTEM DESCRIPTION

- A. Supervisory Control and Data Acquisition (SCADA) Contractor shall provide:
 - 1. A fully assembled and operational MOSCAD RTU and Demarc control Panel.
 - 2. All wiring, conduit, panels, for all SCADA controls and data acquisition.
 - 3. All final electrical connections.
 - 4. Contractor shall be responsible for all electrical work associated with the SCADA system and as called for on the Drawings.
 - a. Perform all wiring in accordance with all local and national codes.
 - b. Install all line voltage wiring, concealed or exposed, in accordance with Division 26.
 - c. All low voltage electrical control wiring throughout the building shall be installed in accordance with Division 26.
- B. General Product Description:
 - 1. The supervisory control and data acquisition system (SCADA) shall provide control and data acquisition to remote equipment sites. The functions including equipment supervision and control, alarm management, energy management, and data collection. The Supervisory Control and Data Acquisition system shall be fully compatible and shall be fully integrated with the existing Wake County system. MOSCAD-L or MOSCAD-M are not acceptable.
 - 2. The supervisory control and data acquisition system shall consist of the following: Motorola MOSCAD RTU, DEMARC Panel and all required accessories.

1.5 SUBMITTALS

- A. General: Submit each item in this Article according to the Conditions of the Contract and Division 01 Specification Sections. A minimum of 7 complete sets of documents are required. Submit 3 copies of all submittals to owner at time of submittal to the architect.
- B. Manufacturer's Product Data for each and all types of products specified. Include manufacturer's technical Product Data for each device furnished, indicating dimensions, capacities, performance characteristics, electrical characteristics, finishes of materials, installation instructions, and startup instructions.
- C. Shop Drawings from manufacturer detailing equipment assemblies and indicating dimensions, weights, loadings, required clearances, method of field assembly, components, and location and size of each field connection.

- D. Certificate for Motorola Certified MOSCAD Solution Provider and certificate for Wonderware Certified System Integrator from preferred vendor (prime or subcontractor).

1.6 PROJECT RECORD DOCUMENTS

- A. Submit under provision of Division 01.
- B. Accurately record actual location of components, including but not limited to, panels and sensors.
- C. Revise shop drawings to reflect actual installation.
- D. Provide hard copy and electronic files

1.7 OPERATION AND MAINTENANCE DATA

- A. Submit under provisions of Division 01.
- B. Maintenance instructions and spare parts list for each type of device.
- C. Interconnection wiring diagrams with identified and numbered system components and devices.
- D. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
- E. Calibration records and list of set points.

1.8 QUALIFICATIONS & QUALITY ASSURANCE

- A. Materials and equipment shall be the catalogued products of manufacturers regularly engaged in production and installation of SCADA systems and shall be manufacturer's latest standard design that complies with the specification requirements.
- B. Install system using competent workmen who are fully trained in the installation of SCADA equipment.
- C. Motorola MOSCAD equipment and related programming will be executed by a firm which is both a Motorola Certified MOSCAD Solution Provider and Wonderware Certified System Integrator.

1.9 INPUT/OUTPUT SUMMARY

- A. Refer to the drawings.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Motorola.
- B. No others will be accepted.

2.2 MOSCAD RTU

- A. General:
 - 1. The remote terminal unit (RTU) shall be an intelligent, modular unit capable of both data acquisition and local data processing. It shall monitor and control local equipment in a stand alone mode as well as being an intelligent node in a distributed processing system. It shall be microprocessor based and allow reconfiguration and optimization to occur via software only. To facilitate installation, maintenance and future expansion, all Input/Output (I/O) modules shall connect to the basic processor module via a passive motherboard on the RTU rack. A PC-compatible computer running a single, comprehensive standard

application development and diagnostic software package shall be used for program development and downloading (directly to the RTU).

Each RTU must be supplied with the number and type of I/O points as indicated elsewhere in the plans and specifications. Future expansion shall be possible by simply plugging in additional I/O modules to the I/O bus. Each RTU shall be supplied with the following minimum configuration:

- a. Mother Board.
- b. Power Supply.
- c. I/O Bus.
- d. Battery.
- e. Enclosure.
- f. I/O Modules as required.
- g. CPU Processor Module.
- h. Communications Interface.

B. Communications:

1. General: The RTU shall support the establishment of a sophisticated data communication network for SCADA applications utilizing ethernet, and Cradle-Point cellular modem. and flash port upgradeable. Communications shall be provided both over ethernet and cellular modem via a second ethernet port.
2. Data Protocol: Data communications shall utilize a secure, smart protocol designed in accordance with the Open System Interconnection (OSI) model as defined by the International Organization for Standardization (ISO). The protocol should allow flexible, efficient communications for transmission of data, complete programs, databases or other parameters. Complete configuration and diagnostic programs shall be transferable from/to the Central site (full data upload/download capability). Complete RTU/system debugging shall be allowed without visiting each remote site. The protocol shall support a complex hierarchical system structures of multiple host computers and sub-master stations. Its detail structure, however shall be transparent to the system user and allow him to concentrate upon the application.

C. Communications Methods:

1. In addition to the simplistic master/slave polling configuration, the RTU shall operate in a number of more efficient contention formats required by point to multipoint networks. The RTU must support quiescent operation and initiate data transmissions under the following conditions:
 - a. Report by Exception - Automatically transmit upon defined exception condition(s); analog, digital or any combination.
 - b. Timed Transmission - Automatically transmit data on programmed time interval.

D. Hardware Modules:

1. Basic Processor Module: The basic processor module (CPU) of the RTU shall be a real time process controller and support:
 - a. Bus communication with I/O modules.
 - b. System memory allocation.
 - c. System parameter/logic programming.
 - d. Communication port control.
2. The Central Processing Unit (CPU) shall be a high speed (200MHz), 32 bit microprocessor, Motorola MPC8270 or equivalent. This VLSI design must incorporate a separate co-processor to handle all external communication tasks so as to not affect base CPU performance.
3. The CPU shall be equipped with a minimum of 16 mbyte on-board memory of different types.

EPROM -	for system programs
RAM -	for data and parameters
FLASH(EEPROM) -	for application programs

- Total RTU memory must be expandable to a minimum of 32 Mbyte. Provision must be available to add a numerical co-processor with true double precision floating point capabilities along with additional memory and support for trigonometric and transcendental functions.
4. The CPU module must incorporate a real-time clock (RTC) with lithium battery backup for both RTC and module RAM. Large scale CMOS gate array technology must be used for minimum component count and maximum performance and reliability. CPU features include:
 - a. Watch-dog timer (WDT).
 - b. Symbolic debugging support.
 - c. Diagnostic LED indication.
 - d. Power monitor for clean program start/stop.
 5. The CPU module must include at least the three built-in communication ports as listed below:
 - a. Port 1: RS-232 or RS-485, software controlled, full DCE/DTE operation to 9600 bps.
 - b. Port 2: RS-232, full DCE/DTE, 9600bps, transient protected.
 - c. Port 3: 10/100 Mbps ethernet module for connection to Cradle-Point modem.
 6. Support shall be available for additional serial channels, wireline or other external communications.
- E. Input/Output Modules:
1. The RTU shall address variable I/O requirements by the addition of appropriate expansion modules. Each module shall communicate with the CPU module via a high speed (> 1 Mbps) data bus. Up to 44 modules shall be supported by a single CPU module; dual CPU configurations shall optionally be available. Each expansion module may be plugged into an empty slot on the I/O bus.
 2. All modules, regardless of type (unless specifically noted), must share the following features:
 - a. Input Protection: dc/dc converter with 2.5kv optical isolation per IEEE SWC 472/587.
 - b. Output Protection: 1 kv between contacts, 1.5kv between contact and coil per IEEE SWC 472 CMOS Gate Array: all logic, bus and LED interface contained in one gate array on each module to minimize components and increase reliability
 - c. Diagnostics: Loopback test, system clock, WDT, 20 diagnostic LED indicators of status and module failure modes.
 - d. Terminal Boards: Removable, Phoenix type up to 14 AWG (2.5 sq. mm) or DIN connector.
 3. Module Identification: Check hardware I/O versus application specification.
 4. Digital Input Module - Type 1:
 - a. Capacity: 16 dry contacts, all isolated inputs; 2 high speed counters (up to 10 KHz).
 - b. Counters: All base inputs may be defined as low speed counters, 50-500Hz.
 - c. Interrupt-Handling: Change of State (COS) reporting to 1 ms in interrupt mode.
 - d. Input filtering 1-32 ms, software controlled.
 5. Digital Output Module:
 - a. Capacity: 16 electrically-energized relay contacts.
 6. Analog Input Module:
 - a. Capacity: 8 floating, isolated inputs.
 - b. Type: 4-20Ma.
 - c. Resolution: 13 bits including sign.
 - d. Accuracy/Linearity: ± 0.05 % full scale/ ± 1 LSB.
 - e. Calibration: Automatic, software controlled (no potentiometer).

7. Analog Output Module:
 - a. Capacity: 4 optically isolated outputs.
 - b. Type: 0-5 V or 4-20Ma performance dependent upon power supply.
 - c. Resolution: 12 bits including sign.
 - d. Accuracy: ± 0.1 % full scale.
- F. Construction:
 1. The RTU shall be totally modular in design and construction, allowing specific configuration merely by plugging in the appropriate CPU and I/O modules. All modules and their assembly shall be accomplished without screws or fasteners of any type. All connections shall utilize a "snap-in" action and a tool shall be supplied to aid easy connector removal. The RTU shall be available in several sizes to fit different application requirements including 3, 6, 8 and 16 module assemblies. Basic RTU models shall consist of a mounting plate and motherboard, a CPU module (occupies 1 slot) and a power supply/charger.
 2. All elements must use CMOS components and LSI circuitry. No jumpers, DIP switches, or adjustable potentiometers shall be allowed. Extensive use of SMD (surface mount device) is required.
 3. Front access to all controls, indicators, lithium battery and external cables shall be provided. Motherboard connection to I/O modules shall be direct; no daisy chain or multiple ribbon cable connections allowed.
 4. All I/O modules shall be equipped with a front cover door to serve as: module latch release, wiring identification label and terminal board protection. Space shall be available to direct and route external wires from outside the RTU that are connected to the I/O modules.
- G. Enclosures:
 1. The RTU shall be wall mounted NEMA 4X, stainless steel.
- H. Environmental:
 1. The RTU must operate over an ambient temperature range of -30 to +60 degrees C with relative humidity < 95% @ 50 degrees C. It must meet or exceed EIA standards RS-204B and RS-152B.
 2. The RTU shall meet or exceed the SWC standards as defined in IEEE C37.90A for all inputs and outputs. In the appropriate enclosure, the RTU shall meet all qualifications for UL 611, paragraph 26.
 3. The RTU shall operate from 115/230 VAC, $\pm 15\%$, 50/60 Hz primary power. A battery and charging circuit shall be included to provide 4 hour standby operation (for defined RTU capacity and use). Larger capacity batteries shall be available to extend operating time.
- I. Application Software & Related Programming:
 1. Operating System: The software shall be based upon a multi-tasking executive system optimized for real-time environments, Motorola's Object Oriented MTE or equivalent.
 2. Application Software: The RTU shall be programmed with a high level, multiple process ladder diagram language which includes Boolean and arithmetic functions as well as specialized function blocks such as proportional, integral, derivative (PID) control and American Gas Association (AGA) flow calculations. The ladder diagrams shall be used for process definitions as well as symbolic monitoring and debugging.
 3. Motorola MOSCAD hardware must be programmed and configured with the appropriate RTU software application program by Motorola 'Certified MOSCAD Solution Provider' / Wonderware Certified System Integrator firm.
 4. The MOSCAD engineer will program/download the application program to be executed in the RTU utilizing the Programming Toolbox. This includes but is not limited to downloading the site configuration, application program and network configuration.
 5. RTU shall be Motorola ACE3680.

2.3 DEMARC PANEL

- A. Enclosure shall be AM Products, series JIC size junction box, stainless steel.
- B. DIN Rail shall be Automation Direct, Rail # DN-R3551.
- C. Terminal blocks shall be Automation Direct # DN-T10, gray, DN-T10-BLK, black, DN-T10-GRN, green.
- D. Loop power supply shall be Automation Direct # PS24075D.

2.4 INPUT/OUTPUT SENSORS

- A. AC current transducer shall be an American Aerospace Controls, Inc., series 100 SX, 4 to 20 mA, 2 wire operation.
- B. Room temperature transmitter shall be Kele Model ST-T91E, 1000 OHM platinum room temperature transmitter.
- C. AC voltage transducer shall be an American Aerospace Controls, Inc., series VX, 4 to 20 mA loop powered.
- D. Monitoring system battery voltage system shall be Engineering Concepts Unlimited, Inc., Model ECU-VLD2-12 for 12 volt system or Model ECU-VLD2-24 for 24 volt system.
- E. Electronic engine speed sensor shall be Thomson Technology Model FSR 230.
- F. Single station level switch shall be Gems sensor.
- G. Relay shall be cube electro-mechanical type with LED. The relay shall be rated for ampere and voltage as required for the application.
- H. Relay sockets shall be compatible with cube relay.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that field end devices and wiring are installed before proceeding with installation.

3.2 INSTALLATION MEETINGS

- A. The contractor shall attend the following meetings with the Designer and Owner. **The SCADA installer shall be present at all of these meetings as well:**
 - 1. Pre-Submittal Meeting. This meeting will cover requirements necessary for submission of shop drawings and manufacturer product data.
 - 2. Pre-Installation Meeting. This meeting will take place no sooner than 2-weeks prior to and no later than 1-week of installation of wiring components at the generator and ATS.
 - 3. Pre-SCADA Start-Up Meeting. This meeting will take place after the contractor has completed the installation of all SCADA components.
 - 4. SCADA Start-Up and Testing. This meeting will take place after the Owner has verified communications with the SCADA system. All points will be tested in the presence of the Owner and Designer. Multiple tests may be necessary until the Owner and Designer have verified proper operation.

3.3 INSTALLATION

- A. Install equipment as indicated to comply with manufacturer's written instructions.
- B. Verify location of sensor and panels with plans before installation.
- C. Install labels and nameplates to identify components.
- D. Install electrical work in accordance with Division 26. Electrical material and installation shall be in accordance with the appropriate requirements of Division 26.

3.4 MANUFACTURERS' FIELD SERVICES

- A. Prepare and start systems under the provisions of Division 01.
- B. Start-up systems. Allow sufficient time for start-up prior to placing systems in permanent operation.

3.5 COMMISSIONING

- A. Test and adjust safeties and communications.
- B. Replace damaged or malfunctioning components and equipment.
- C. Start, test, and adjust systems.
- D. Demonstrate compliance with requirements.

3.6 DEMONSTRATION

- A. Demonstrate a complete and fully operational system to the Owner.

END OF SECTION 26 99 99

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SECTION 27 00 00 – GENERAL TELECOM REQUIREMENTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Voice, Data, and Fiber Cable Product materials
- B. Voice, Data, and Fiber Cable Execution directions

1.2 RELATED DOCUMENTS

- A. Drawings and general provision of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.3 SYSTEM DESCRIPTION

- A. A cable system consisting of copper cables, routed between various telecommunications outlets and their designated telephone room.

1.4 CONTRACTOR DELIVERABLES/PRELIMINARY MEETINGS

- A. In the bid response, the Contractor shall provide a complete and itemized list of products intended for use, warranty documentation for the products chosen, and credentials for the personnel who will lead this project.
- B. Prior to shop drawing submittals, an Initial Planning Meeting will be held for the Contractor and the Owner to clarify all requirements (systems, services, distribution methods, etc.), to identify responsibilities, and to schedule the events that will transpire during the implementation of the project.
- C. At the subsequent Product and Design Meeting, the Contractor will bring product submittals for each component of the proposed system, and be prepared to ask any questions related to installation. No material shall be ordered or installed until reviewed and approved by the Owner and Designer.

1.5 QUALITY ASSURANCE

- A. The Contractor shall be a firm with at least 5 years of experience of successful installation experience with projects utilizing unshielded twisted pair cabling (UTP), Category 5E and Category 6 in compliance with EIA/TIA-568.
- B. The Contractor shall have a permanent service organization with an office located within thirty miles of project site.
- C. The firm must have an RCDD on staff. In addition, the lead technician MUST be BICSI certified at the Technician Level prior to leading the installation of cabling on the project. The same technician must be the lead technician for the duration of the project or be replaced by a technician with the same credentials.
- D. The Contractor shall utilize certified cable technicians with approved manufacturer-specific certification.
- E. The Contractor shall perform all installation work according to the principles outlined in:
 - 1. ANSI/TIA/EIA-568B: "Commercial Building Telecommunications Cabling Standard"
 - 2. ANSI/TIA/EIA-569: "Commercial Building Standard for Telecommunications Pathways and Spaces"

3. ANSI/TIA/EIA-606: "Administration Standard for Telecommunications Infrastructure of Commercial Buildings"
 4. NFPA 70: "National Electrical Code"
 5. BICSI Telecommunication Distribution Methods Manual
 6. IEEE Bonding and Grounding Best Practices
 7. And generally accepted industry practices
- F. The Contractor shall provide materials that are NRTL (Nationally Recognized Testing Laboratory) listed and labeled, as defined in the "National Electrical Code," Article 100 and FCC Regulations, "Title 47 of the Code of Federal Regulations", Part 68, Chapter 1.

1.6 GENERAL REQUIREMENTS

- A. The Contractor shall provide any necessary screws, anchors, clamps, tie wraps, distribution rings, miscellaneous grounding and support hardware, etc. necessary to facilitate the installation of the system in a neat and orderly fashion.
- B. It shall be the responsibility of the Contractor to furnish any special installation equipment or tools necessary to properly complete the system. This may include, but is not limited to, tools for terminating, testing, and splicing copper cables, jack stands for cable reels, and/or cable winches.

1.7 WARRANTY/REPAIR SERVICE

- A. The Contractor shall provide a two (2) year warranty for both products and labor.
- B. The Contractor must provide repair service within sixteen business hours for routine service, and within eight business hours of notification for outages deemed by the Owner to be an Emergency, which includes but is not limited to outages of more than five stations or a critical emergency service station.

PART 2 - PRODUCTS

2.1 GENERAL

- A. All like items of products provided must be new and of the same manufacturer and meet the performance requirements for that item as shown in this specification or industry standards, whichever is more stringent.
- B. All system components must be selected and installed as a complete systems-solution, providing a manufacturer's certified warranty for a minimum of five years.
- C. Approved systems solutions manufacturers are:
 1. Essex Cable Ortronics Station Outlets Ortronics Patch Panels
 2. Commscope Cable Uniprise Station Outlets Uniprise Patch Panels
 3. General Cable Panduit Station Outlets Panduit Patch Panels
- D. Return air plenum environments are indicated on the drawings. All cables shall meet or exceed the appropriate flame-retardant requirement for the area in which they are installed (NEC type-requirements).

2.2 STATION CABLE

- A. All station cables shall be CAT 6, 4-pair, UTP, non-stranded, and colored green, unless otherwise specified.
- B. Further, cables that will be placed in conduit in slab on grade must be water-blocked, indoor-outdoor rated and suitable for underground service.

- C. All cables shall be composed of 24 AWG solid copper conductors. All cables shall be Underwriter's Laboratories (UL) listed type MPR, MPP, CMR, and CMP. Cable shall also support IEEE 802.3, 10BASE-T, and IEEE 802.5 standards.
- D. Approved manufacturers are Essex, Commscope, and General.

2.3 TELECOMMUNICATIONS STATION OUTLETS

- A. Standard Wall Station Outlet: Each standard wall faceplate shall be four (4) position, brushed stainless steel, mounted on single gang outlet box, to accommodate RJ45 jacks. Each standard wall faceplate shall contain two (2) CAT 6 compliant RJ45 modular jacks, color-coded red and ivory, to accommodate two cables, plus two blank inserts.
- B. Data-only Outlet: Each data-only faceplate shall be six (6) position, brushed stainless steel, mounted on single gang outlet box, to accommodate RJ45 jacks. The exact number of jacks and cables for each data-only outlet will be marked by subscript next to the jack designation on the plans. CAT 6 compliant RJ45 modular jacks will be colored-coded gray, with blank inserts in spare positions.
- C. Floor Outlets : Each floor outlet faceplate shall contain CAT 6 compliant RJ45 modular jacks, to accommodate RJ45 jacks. The exact number of jacks and cables for each data-only outlet will be marked by subscript next to the jack designation on the plans. CAT 6 compliant RJ45 modular jacks will be colored-coded gray, with blank inserts in spare positions.
- D. Wireless Access Point Outlet: Each access point outlet shall consist of two (2) CAT 6 cables, with one (1) terminated in an RJ45 modular plug, to be left in the ceiling with a 30' service loop. Cables will be terminated in the Special-Use patch panel, with RJ45 modular jack inserts, clearly labeled.
- E. Approved station outlet manufacturers are Ortronics, Uniprise, or Panduit, as specified in 2.0.C.

2.4 PATCH PANELS

- A. STANDARD station cables shall be terminated on 19" rack-mounted 48-port CAT 6 angled patch panels, with 110 crossconnect terminations, wired in the T568B configuration. The first jack of each outlet (red) will be terminated on the first patch panel, designated for red jacks. The second jack of each outlet (ivory) will be terminated on a corresponding second patch panel designated for ivory jacks. The Contractor shall provide sufficient quantity of patch panels in each telephone room to terminate all station cables shown on plans, plus 20% spare capacity for future station jacks.
- B. Data-only cables will be terminated on dedicated data-only patch panels. Those data-only patch panels shall be 19" rack-mounted CAT 6 angled 48-port patch panels, with 110 crossconnect terminations, wired in the T568B configuration. The Contractor shall provide sufficient quantity of data-only patch panels in each telephone room to terminate all data-only station cables shown on plans, plus 20% spare capacity for future station jacks.
- C. Special-use cables, such as cables between the MDF and IDF's and cables serving wireless access points shall be terminated in rack-mounted 12-port or 24-port angled patch panels (24-port for IDF 144 and 12-port patch panels for each MDF 213 and IDF 155), which accept 6-port jack module inserts.
- D. The module inserts for cables between telephone rooms must be yellow or have yellow jacks to easily distinguish use. The module inserts for wireless access points may be gray or white.
- E. All hardware shall meet or exceed the reliability, attenuation, and NEXT requirements of TIA-568B. The panels shall be able to accommodate 500 repeated insertions without incurring permanent deformation, and shall pass the reliability test of no more than one contact failure in 10000 connections. The panels shall be able to accommodate 24 AWG cable conductors, and be Underwriter's Laboratories (UL) listed.

2.5 EQUIPMENT RACKS

- A. Unless otherwise specified, two EIA standard (7' x 19") black aluminum equipment racks are required for the telephone room. All equipment racks shall be capable of supporting 600 pounds, with type B universal mounting rail pattern. (A third equipment rack will be provided by the AV vendor.)
- B. Vertical wire management shall be provided on each side of racks, with one unit between racks. Vertical wire managers shall be black 7-foot, double-sided (front and rear) units, with finger openings, hinged front cover, and all brackets and connectors necessary for a complete system.
- C. The basis of design product is Chatsworth 30095-703 (6"). Substitutions may only be submitted for approval during the pre-bid process.
- D. Each equipment rack shall be equipped with one rack-mounted horizontal power strip, providing at least six (6) 20 ampere, 120-volt receptacles, having a cord at least 10' long.
- E. Each rack shall be equipped with one 2RU section of horizontal wire management, with hinged cover, which matches the vertical wire manager.
- F. **Provide Wake County Standard UPS in bottom of one (1) rack. Vertiv GXT5-2000 with RDU101 Webcard.**

2.6 PATCH CORDS

- A. The Contractor shall supply factory-prepared eight (8)-conductor modular CAT 6, 28-gauge patch cords with male RJ45 connector on each end, for connection of network port to patch panels. Patch cords shall have a T568B wiring/pin configuration and colored yellow. One patch cord is required for each station outlet, plus an additional 30% for future growth. Of the cords supplied, 50% shall be seven (7) feet long, 40% shall be ten (10) feet long, and 10% shall be twelve (12) feet long.

2.7 CABLE SUPPORTS

- A. The contractor will provide and install horizontal ladder rack in each telephone room. The installation is intended to support cables across the longest wall of the closet, and to connect each equipment rack to the wall. The ladder rack shall be 18" wide of tubular steel, with rungs 9" on center.
- B. Acceptable product is Hoffman Model LSS18BLK, or equivalent.

2.8 HANGERS

- A. The Contractor shall use approved J-hooks or other CAT 6-rated cable support hangers in ceiling void.

2.9 LABELS

- A. All Labels used to mark cables, faceplates, patch panels and distribution hardware shall be of the self-laminating type, and shall be machine-printed with black ink on white background. Labels will have pressure sensitive, permanent acrylic-type adhesive. All labels will be uniform in size using the same font size on letters and numbers throughout. Label printing will be 1/8" minimum in block style.

PART 3 - EXECUTION**3.1 TELEPHONE ROOMS**

- A. Prior to working in the telephone rooms, the Contractor shall ensure that, at a minimum, a #6 AWG green insulated copper grounding conductor has been provided.
- B. The ladder racks shall be placed according to the telephone room layout, and securely fastened to the wall and the equipment racks to support the weight of cables.
- C. In each closet, the equipment racks shall be bolted to the floor and top-braced by connection to the ladder rack.
- D. Each equipment rack and each section of ladder rack shall be properly bonded to an approved building ground.
- E. Electric outlet strips should be installed in the middle of each rack. The power cord will be securely connected to the electrical outlet provided for that purpose, routing the power cord over the top of the rack, or routed through the channel to the UPS.
- F. D-rings are to be installed in telephone rooms to protect cables in transition.

3.2 COPPER CABLE INSTALLATION

- A. Layouts for all telephone rooms will be provided by the Owner, and must be received by the Contractor before work can begin. The approved closet layout should be posted in each closet.
- B. In all wiring closets, install cables parallel and at right angles to walls. Bundle, lace and train the conductors to terminal points with no excess. Use wire distribution spools at points where cables are fanned, or conductors turned.
- C. Terminate conductors of cables on terminal block using tools recommended by terminal block manufacturer.
- D. All cables shall be run concealed in accessible ceiling space, unless otherwise indicated by the owner, or on the plans. No exposed copper cable will be permitted, unless written authorization is secured from the engineer.
- E. Cables shall be routed along the most direct path between the outlet and the wiring closet, however all paths shall run parallel and perpendicular to corridors. Diagonal routing shall not be permitted. All cable shall be routed in a neat and orderly manner, using installed cable tray or ladder rack whenever possible.
- F. It is imperative that all cables are properly secured to the building structure at intervals as required to prevent sagging between supports, as per NEC 800. Cables must be supported every four to five feet, and may not rest on ceiling tiles, nor be secured to improper structures such as ceiling grid or conduits. Only J-Hooks or hangers approved for CAT 6 cable may be used.
- G. Cables must not be spliced between the normal terminations of runs.
- H. Cable shall be installed without damaging conductors or jacket. The Contractor shall ensure that the manufacturer recommended maximum pulling tensions and cable bends of the specified distribution cables are not exceeded. Failure to follow the appropriate guidelines will require the Contractor to provide, in a timely fashion, the additional material and labor necessary to properly rectify the situation. This shall also apply to any and all damages sustained to existing cables by the Contractor during the implementation.
- I. The Contractor shall pull cables simultaneously where more than one is being installed in the same raceway or at the same location. Use pulling compound or lubricant where necessary. Compound used must not damage conductor or insulation. Use pulling methods that will not damage cable or raceway, including fish tape, cable, rope, and wire-cable grips.
- J. Cable routing shall avoid contact or close proximity to power lines, conduits, lighting fixtures, and other potential sources of interference, and shall not share the same conduit, channel or sleeve with any electrical apparatus.
- K. To facilitate future rearrangements, a three-foot (3') service loop shall be allowed for cables in the wiring closet, with slack routed neatly on the ladder rack. Cables installed in raceways from ceiling space to outlet boxes, shall have a 12" repair loop above the ceiling, at transition from

horizontal to vertical drop. Cables installed for cubicles shall be placed with a 5" slack loop in the raceway.

- L. The amount of cable jacket removed from the end of cables shall be kept to a minimum. Never remove the jacket more than specified by the manufacturer to achieve manufacturer certification. The Contractor shall maintain the twist integrity of each cable pair up to the point of termination.
- M. The Contractor will make every effort to install cables to maintain numerical order in a clockwise sequence around each floor, according to the numbering scheme provided by the Owner.
- N. On the patch panels and punchdown blocks, sequential, numerical order shall be maintained. Numbering shall be from left to right and from top to bottom with consecutive numbers, skipping no spaces.
- O. The Contractor shall properly fire stop all penetrations through fire-rated walls with an approved material to restore the original fire rating.
- P. Wake County reserves the right to reject workmanship that does not meet this requirement.

3.3 TELECOMMUNICATIONS STATION OUTLETS INSTALLATION

- A. STANDARD outlets terminated in a four-pair faceplate will contain two CAT 6 4-pair cables, terminated on RJ45 CAT 6 jacks, color-coded red and ivory, plus two blank inserts.
- B. Data-only outlets will contain multiple CAT 6 4-pair cables, with the number of cables denoted by subscript on the plans. All data-only cables will be terminated in CAT 6 RJ45 jacks, color-coded gray.
- C. Floor outlets will contain two 4-pair CAT 6 cables, terminated on CAT 6 RJ45 jacks, color-coded red and ivory, as described in section 2.2.C, UNLESS OTHERWISE NOTED.
- D. Wireless access point outlets shall consist of a single CAT 6 cable, terminated in an RJ45 modular plug, to be left in the ceiling, with a 30' service loop, UNLESS OTHERWISE NOTED.

3.4 LABELING

- A. Station cables shall be labeled within four inches of each end, behind the faceplate and in the wiring closet. Jack numbers shall match exactly at both ends of all cables.
- B. There will be a single label on each STANDARD faceplate. Jack numbers will be comprised of the destination closet, and the assigned station number. Example: Label "144-36" corresponds to a station outlet served from Room 144, with station number 36. In a standard faceplate, it is understood that the "red" cable will be routed to a port on the "red" patch panel and the "ivory" cable to the "ivory" patch panel. Gray data-only cables will be routed to a gray patch panel.
- C. Printed labels on the outlet faceplate shall be mounted above the jack positions, so they can be easily read when patch cords are in place.
- D. All backbone cables shall be clearly labeled with an indication of the destination closet at both ends and at all likely access points. The labels shall be placed in conspicuous locations in the vicinity of the termination fields as well as at every pull box or secondary junction point.
- E. All copper patch panels shall be labeled to identify the panel with the Room number, plus "Red", "Ivory", or "Gray". Ex: "IDF 144-Red" corresponds to a panel in IDF Room 144.
- F. Numbering on all panels shall be from left to right and from top to bottom, with consecutive numbers, skipping no spaces.

3.5 ACCEPTANCE TESTING

- A. A. The Owner shall be given the opportunity to witness testing. The Contractor shall submit a testing schedule at least three (3) business days prior to initial testing.
- B. B. All copper cables shall be tested. Sample testing shall not be permitted. All tests shall be performed on the completely installed system, through all terminations, in the system's final state, as it will be turned over to Wake County.
- C. C. All cables shall be tested for:

1. Continuity [pass/fail]
 2. Proper termination sequence [pass/fail]
 3. Cable length (measured electronically) [feet]
 4. Line attenuation, indicate frequency [dB @ MHz]
 5. Signal-to-noise ratio (with active hubs) [dB]
 6. Ambient line-noise level [dBm]
 7. Shorts between any two or more conductors
 8. Crossed pairs, reversed pairs, split pairs, and other mis-wirings
 9. Bi-Directional near-end crosstalk (NEXT) shall be tested on all six pair combinations in each four pair cable. Tests for NEXT shall be performed from both the work area outlet location and link origination point.
- D. The initial computer-generated test results, including failures, shall be submitted to the Owner, in both printed and electronic formats. All test data shall indicate the date of the test and the name of the persons that performed the test.
- E. The Contractor shall then correct deficiencies indicated by tests and completely retest work affected by such deficiencies. The Contractor shall submit computer-generated retesting results, in both formats.

3.6 DOCUMENTATION

- A. The Contractor shall submit an electronic copy of equipment warranty documentation to Wake County.
- B. At the conclusion of the project, the Contractor shall furnish two hard copies of as-built floor plans for each floor, clearly indicating each outlet number and location. One copy of these documents shall be posted in each telephone room and the other provided to Wake County Telecommunications.
- C. The Contractor shall also submit this as-built document to the engineer or Wake County in .DWG or .DXF format on CD-ROM or flash drive.
- D. The documentation shall include a spreadsheet (Microsoft Excel compatible format) with information presented in the following format:

Building Name	Wake County	West Regional Center
Telecom Room	Jack Numbers	Room Connected to
3rd Floor South	3S01	357
5th Floor North	5N36	End of hall room, lab

Cat6 Wiring Specifications Parts List Below

ITEM DESCRIPTION	PANDUIT/GENERAL PARTS	ORTRONICS/ESSEX PARTS	UNIPRISE/COMMSCOPE PARTS	CHATSWORTH PART
FACEPLATE 4 PORT SG	CFP4SY	OR 403STJ14	UNF-MFM-4P-ST	
FURNITURE BEZEL	CFFPL4-1W	OR 40300633	UNF-MF-4P-BK	
BLANKS FOR FACEPLATE	CMB-1W	OR 42100002	UNDC-1W	
JACK CAT 6	CJ688TG	OR TJ600	UNJ600	
PP 48 PORT ANGLED CAT 6	DPA48688TGY	OR PHA66U48	UNP610ANG-48P	
PP 24 PORT ANGLED CAT 6	DPA24688TGY	OR PHA66U24	UNP610ANG-24P	
'GFCI' FRAME	CFG4-1W	NA	NA	
PATCH CABLE 7' YELLOW CAT6	UTPSP7YLY	OR-MC607-04	UNC6-YL-7F	
PATCH CABLE 7' GRAY CAT 5E	UTPCH7Y	OR-MC5E07-08	UNC5-GY-7F	
VERTICAL CABLE MANAGER	NA	NA	NA	CPI 30095-703
HORIZONTAL CABLE MANAGER	NA	NA	NA	CPI 30330-719
CA. 4 PR. IN BOX GREEN CAT6	GENERAL 7131806	ESSEX 77-240-5B	6504-GR	
CA. OSP CAT 6	GENERAL 7136100	ESSEX 04- 001-68	COMMSCOPE 6NF4PLUS	

END OF SECTION 27 00 00

SECTION 27 05 28 - PATHWAYS FOR COMMUNICATIONS SYSTEMS**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes:
 - 1. Metal conduits and fittings.
 - 2. Optical-fiber-cable pathways and fittings.
 - 3. Hooks.
 - 4. Boxes, enclosures, and cabinets.

1.2 ACTION SUBMITTALS

- A. Product data for each type of product.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Pathway routing plans, drawn to scale and coordinated with each other, using input from installers of items involved.
- B. Qualification Data: For professional engineer.

PART 2 - PRODUCTS**2.1 METAL CONDUITS AND FITTINGS**

- A. Description: Metal raceway of circular cross section with manufacturer-fabricated fittings.
- B. General Requirements for Metal Conduits and Fittings:
 - 1. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.
 - 2. Comply with TIA-569-D.
- C. EMT: Comply with ANSI C80.3 and UL 797.
- D. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.
 - 1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 1203 and NFPA 70.
 - 2. Fittings for EMT:
 - a. Material: Steel.
 - b. Type: Compression.

2.2 OPTICAL-FIBER-CABLE PATHWAYS AND FITTINGS

- A. Description: Comply with UL 2024; flexible-type pathway with a circular cross section, approved for riser installation unless otherwise indicated.
 - 1. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
 - 2. Comply with TIA-569-D.

2.3 HOOKS

- A. Description: Prefabricated sheet metal cable supports for telecommunications cable.
- B. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- C. Comply with TIA-569-D.
- D. Galvanized steel.

- E. J shape.

2.4 BOXES, ENCLOSURES, AND CABINETS

- A. Description: Enclosures for communications.
- B. General Requirements for Boxes, Enclosures, and Cabinets:
 - 1. Comply with TIA-569-D.
 - 2. Boxes, enclosures, and cabinets installed in wet locations shall be listed and labeled as defined in NFPA 70, by an NRTL, and marked for use in wet locations.
 - 3. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
 - 4. Device Box Dimensions: 4 inches square by 2-1/8 inches deep (100 mm square by 60 mm deep).
- 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, Type FD, with gasketed cover.
- E. Metal Floor Boxes:
 - 1. Material: Cast metal.
 - 2. Type: Fully adjustable.
 - 3. Shape: Rectangular.
 - 4. Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- F. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- G. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, cast aluminum with gasketed cover.

PART 3 - EXECUTION

3.1 PATHWAY APPLICATION

- A. Minimum Pathway Size: 1-inch trade size.
- B. Pathway Fittings: Compatible with pathways and suitable for use and location.
- C. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.
- D. Install surface pathways only where indicated on Drawings.

3.2 INSTALLATION

- A. Comply with the following standards for installation requirements except where requirements on Drawings or in this Section are stricter:
 - 1. NECA 1.
 - 2. NECA/BICSI 568.
 - 3. TIA-569-D.
 - 4. NECA 101
 - 5. NECA 102.
 - 6. NECA 105.
 - 7. NECA 111.
- B. Comply with NFPA 70 limitations for types of pathways allowed in specific occupancies and number of floors.
- C. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.
- D. 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.
- E. Complete pathway installation before starting conductor installation.

- F. 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.
- G. Support conduit within 12 inches (300 mm) of enclosures to which attached.
- H. 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.
- I. Stub-ups to Above Recessed Ceilings:
 - 1. Use EMT for pathways.
 - 2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.
- J. 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.
- K. 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.
- L. 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.
- M. 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.
- N. 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.
- O. 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.
- P. Hooks:
 - 1. Size to allow a minimum of 25 percent future capacity without exceeding design capacity limits.
 - 2. Shall be supported by dedicated support wires. Do not use ceiling grid support wire or support rods.
 - 3. Hook spacing shall allow no more than 6 inches (150 mm) of slack. The lowest point of the cables shall be no less than 6 inches (150 mm) adjacent to ceilings, mechanical ductwork and fittings, luminaires, power conduits, power and telecommunications outlets, and other electrical and communications equipment.
 - 4. Space hooks no more than 5 feet (1.5 m) o.c.
 - 5. Provide a hook at each change in direction.
- Q. Mount boxes at heights indicated on Drawings. Install boxes with height measured to center of box unless otherwise indicated.

- R. Horizontally separate boxes mounted on opposite sides of walls, so they are not in the same vertical channel.
- S. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.
- T. Set metal floor boxes level and flush with finished floor surface.
- U. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.3 FIRESTOPPING

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

3.4 PROTECTION

- A. Protect coatings, finishes, and cabinets from damage or deterioration.
 - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.

END OF SECTION 27 05 28

SECTION 28 31 11 - DIGITAL, ADDRESSABLE FIRE-ALARM SYSTEM**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes:
 - 1. Fire-alarm control unit.
 - 2. Manual fire-alarm boxes.
 - 3. System smoke detectors.
 - 4. Heat detectors.
 - 5. Notification appliances.
 - 6. Addressable interface device.
 - 7. Cellular Based Dialer Systems through internal DACT.

1.2 SYSTEM DESCRIPTION

- A. Noncoded, addressable system, with multiplexed signal transmission, dedicated to fire-alarm service only.

1.3 SUBMITTALS

- A. 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 minimum.
- B. Product Data: For each type of product indicated.
- C. Shop Drawings: For fire-alarm system. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Comply with recommendations in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter in NFPA 72.
 - 2. Include voltage drop calculations for notification appliance circuits.
 - 3. Include battery-size calculations.
 - 4. Include performance parameters and installation details for each detector, verifying that each detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
 - 5. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale and coordinating installation of duct smoke detectors and access to them. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators. Locate detectors according to manufacturer's written recommendations.
 - 6. Include floor plans to indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits.
- D. Qualification Data: For qualified Installer.
- E. Field quality-control reports.
- F. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
 - 1. Comply with the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
 - 2. Provide "Record of Completion Documents" according to NFPA 72 article "Permanent Records" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter.

3. Record copy of site-specific software.
4. Provide "Maintenance, Inspection and Testing Records" according to NFPA 72 article of the same name and include the following:
 - a. Frequency of testing of installed components.
 - b. Frequency of inspection of installed components.
 - c. Requirements and recommendations related to results of maintenance.
 - d. Manufacturer's user training manuals.
5. Manufacturer's required maintenance related to system warranty requirements.
6. Abbreviated operating instructions for mounting at fire-alarm control unit.
7. Copy of NFPA 25.
- G. 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.
- H. Points List
 1. Contractor shall submit a preliminary points list for review by the Designer and Owner.
 2. Contractor shall meet with the Designer and Owner, if necessary to review the list after review.
 3. Contractor shall submit final points list after comments have been received. The points list will be utilized by the Owner as a submission to the Central Station. List must be approved no later than 60 days prior to Substantial Completion.

I.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.
- B. Source Limitations for Fire-Alarm System and Components: Obtain fire-alarm system from single source from single manufacturer. Components shall be compatible with, and operate as, an extension of existing system.
- 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.

PART 2 - PRODUCTS

2.1 MANUFACTURER'S/MODELS

- A. Manufacturer's/Models: Subject to compliance with requirements in section 1.3.A above, and to meet UL and NFPA requirements related to use of devices with existing systems, the current manufacturer and corresponding panel models that are acceptable to be incorporated into the contract are limited to the following:
 1. Edwards System Technology (EST3)
 2. Notifier (NSF640 and NSF3030)
 3. FCI (E3)
- B. All fire alarm panels, components and devices shall be non-proprietary and parts, service, etc shall be available from multiple independent suppliers within 100 miles of the project site."

2.2 FIRE ALARM CONTROL PANEL (FACP)

- A. FACP - Minimum Requirements: The CPU shall communicate with and control the following types of equipment used to make up the system: addressable detectors, addressable modules, local and remote operator terminals, printers, annunciators, and other system controlled devices. The main FACP shall perform the following functions:
1. Supervise and monitor all addressable detectors and monitor modules connected to the system for normal, trouble and alarm conditions.
 2. Supervise all initiating, signaling, and notification circuits throughout the facility by way of connection to monitor and/or control modules.
 3. Detect the activation of any initiating device and the location of the alarm condition. Operate all notification appliances and auxiliary devices as programmed.
 4. Visually and audibly annunciate any trouble, supervisory or alarm condition on operator's terminals, panel display, and annunciators.
 5. The FACP shall include a full featured operator interface control and annunciation panel that shall include a backlit, 80 character liquid crystal display, individual, color coded system status LED's, and an alphanumeric keypad for the field programming and control of the fire alarm system.
 6. All programming or editing of the existing program in the system shall be achieved without special equipment and without interrupting the alarm monitoring functions of the fire alarm control panel, and shall be password protected with multiple access levels.
 7. **System shall be modular in construction. Provide "plug&play" style encapsulated components/units that can be inserted into any relevant slot in the panel.**
 8. Shall comply with the UL 9th Edition.
- B. System Capacity and General Operation: The system shall have the following capacities and general operation modes:
1. Signal Line Circuits (SLC's): The FACP shall be capable of connecting the number of devices shown in the drawings to SLC's. Alarm, trouble and supervisory signals from all addressable reporting devices shall be encoded onto a Class A Signaling Line Circuit (SLC), (NFPA Style 6), with the capacity for expansion up to at least 198 total addressable devices per SLC and up to at least 636 total points per system. Each SLC shall not carry more than 80% of its rated load capacity on a new system installation. Provide a minimum of one spare SLC card.
 2. Initiation Device Circuits: Initiation Device Circuits (IDC) shall be wired Class A (NFPA Style D).
 3. Notification Appliance Circuits: Notification appliance circuits shall be wired Class B (NFPA Style Y).
 4. Digitized Electronic Signals: Shall employ check digits or multiple polling. In general a single ground or open on any system signaling line circuit, initiating device circuit, or notification appliance circuit shall not cause system malfunction, loss of operating power or the ability to report an alarm.
 5. Loss of Power: Alarm signals arriving at the main FACP shall not be lost following a power failure (or outage) until the alarm signal is processed and recorded.
 6. System Response to an Alarm Condition: When a fire alarm condition is detected and reported by one of the system initiating devices or appliances, the following functions shall immediately occur:
 - a. The system alarm LED shall flash.
 - b. A local piezo-electric signal in the control panel shall sound.
 - c. The 80-character LCD display shall indicate all information associated with the fire alarm condition including: the type of alarm point, the initiating device address and the description of its physical location within the protected premises.
 - d. History logging of all information associated with the event, including time and date of occurrence.

- e. Activate all system outputs, including program assigned via control-by-event equations, shall be executed by the particular point in alarm. Exact programming shall be provided by the Contractor to meet the Owners requirements.
- f. Activate all fire alarm Notification Appliances in the building, sounding and flashing in synchronization continuously until manually silenced, or until the initiating device and control unit has been reset to normal condition.
- g. Activate digital alarm communicator.
- h. Deactivate door hold control relay such that all smoke doors are allowed to close.
- i. Deactivate control relays allowing HVAC units to stop.
- j. Transmission of all data to any remote annunciation panels.
- 7. System Response to Trouble and Supervisory Conditions:
 - a. The system trouble and/or supervisory LED(s) shall flash.
 - b. A local piezo-electric signal in the control panel shall sound.
 - c. The 80-character LCD display shall indicate all information associated with the trouble or supervisory condition including: the type of device point, the device address and the description of its physical location within the protected premises.
 - d. History logging of all information associated with the event, including time and date of occurrence.
 - e. Activate digital alarm communicator.
 - f. System AC power trouble signal shall not be sent unless maintained for 8 hours (or more).
 - g. Provide adjustable time delay for all trouble signals prior to transmission.
 - h. Transmission of all data to any remote annunciation panels.
- C. Remote Transmissions: The FACP shall be interfaced to an integral, Digital Alarm Communications Transmitter (DACT). The integral DACT shall be connected to an external cellular dialer compatible with the Owner's cellular provider. The DACT shall be equipped with backup batteries with an automatic battery charging circuit, capable of performing a self test every 24 hours any failure shall initiate a trouble condition, generating a 24 hour test report to the receiving station equipment, and dual phone line capability. The following signals, in order of precedence shall be reported as applicable:
 - 1. Fire.
 - 2. Trouble.
 - 3. Supervisory.The unit shall transmit individual addresses and information via contact ID to the Owner's receiving station. Contractor shall coordinate testing with Owner at least two weeks prior to final inspections. **In addition, the system shall be NON-PRIOTIRY; the contractor shall be responsible for all programming of the DACT. Owner's third party monitoring agency shall have no responsibility for programming.**
- D. Power Supply(ies): The FACP power supply(ies) shall operate on 120 VAC, 60 Hz and shall be adequate to power all equipment and functions in full alarm continuously utilizing only 60% of the rated output. Signal circuits shall each be loaded no more than 60% of their rated capacity. All modules and drivers must be able to withstand prolonged short circuits in the field wiring, either line-to-line or line-to-ground, without damage.
- E. Emergency Power Supply: Components include batteries, charger, and automatic transfer circuitry.
 - 1. Batteries: Shall be completely maintenance free, sealed lead calcium construction with fully gelled electrolyte. Battery nominal life expectancy of 15 years, minimum, is required. Battery voltage and capacity shall be determined by the measured load calculations required by the FACP and related connected equipment. Battery shall have sufficient capacity to power the FACP for not less than twenty-four hours standby, plus 5 minutes of full alarm output upon a normal AC power failure.
 - 2. Battery Charger: Solid state, fully automatic, variable-charging-rate type. Provide capacity for 150% of the connected system load while maintaining batteries at full charge. If

batteries are fully discharged, the charger charges them completely within four hours. Charger output is supervised as part of system power supply supervision.

3. Integral Automatic Transfer Switch: Transfers the load to the battery without loss of signals or status indications when normal power fails.
- F. Serial Interface Board: The FACP shall contain a serial interface board to provide an EIA 232 interface between the fire alarm control panel and the UL Listed Electronic Data Processing (EDP) peripherals. The serial interface board shall allow the use of multiple printers, CRT monitors, and other peripherals connected to the EIA 232 ports. In addition, the serial interface board shall provide one EIA-485 port for the serial connection to annunciation and control subsystem components; LED's shall be provided to show operational status. All serial interface input/outputs shall be optically isolated to provide protection from surges and/or earth grounds.

2.3 AUXILIARY POWER SUPPLY PANELS (APS)

- A. APS - Minimum Requirements: All APS(s) shall operate on 120 VAC, 60 Hz and shall have a continuous rating adequate to power all equipment and functions in full alarm continuously utilizing no more than 80% of the total rated ampere output capacity. Additionally, no more than 80% per individual output circuit ampere capacity shall be utilized. All modules and drivers must be able to withstand prolonged short circuits in the field wiring, either line-to-line or line-to-ground, without damage. The APS shall provide a battery charger for 24 hours of standby using dual rate-charging techniques for fast battery recharge. The APS shall be capable of providing a minimum of 24 hours of standby power with an additional 5 minutes in full alarm output, for powering all connected devices. All APS's shall be capable of providing the following general requirements, features, and functions when utilized as an integral part of the system:
 1. Shall be capable of being externally triggered or initiated by the FACP, via an addressable control module, for all required output activations.
 2. Shall provide multiple regulated and conditioned +24VDC output circuits capable of being supervised with on board LED's for fault indication per output circuit.
 3. Shall provide at least (1) one +24VDC auxiliary type output.
 4. Shall be capable of battery supervision with an onboard LED fault indicator.
 5. Shall provide ground fault monitoring circuitry.
 6. Shall provide at least (1) Form "C" dry contact or other on board form of dry contact output that will change states during any fault condition detected, for connection to (1) one addressable monitoring device for individual APS, FACP supervision.
 7. Output circuits shall have the capability of being selectively disabled, via on board switch configurations, during any AC power failures.
- B. Back-up Batteries: Shall be completely maintenance free, sealed lead calcium construction with fully gelled electrolyte. Battery nominal life expectancy of 15 years, minimum, is required. Battery voltage and capacity shall be determined by the measured load calculations required by the APS and related connected equipment. Battery shall have sufficient capacity to power the APS for not less than twenty-four hours standby, plus 5 minutes of full alarm output upon a normal AC power failure.
- C. Enclosures: The APS shall be housed in a UL listed cabinet suitable for surface or semi flush mounting. Cabinet and front shall be corrosion protected, given a rust resistant prime coat, and manufacturer's standard finish. The door shall provide a key lock. For convenience, the door may be hinged on either the right or left side (field selectable). Where multiple enclosures are required in the same area, the cabinets shall all be the same size and color. Cabinet doors must be electrically bonded to enclosure it serves.

2.4 ALARM NOTIFICATION APPLIANCES

- A. Audible Devices: Shall be located as shown on the Drawings; sounders located outdoors shall be listed for use in wet locations and shall have the following specifications:
 1. Voltage: Shall operate on 24 VDC nominal.

2. Programming: Shall be field programmable without the use of special tools, to provide slow whoop, continuous, three pulse temporal or interrupted tones with an output sound level of at least 90 dBA measured at 10 feet from the device.
3. Mounting: Provide surface mounting devices suitable for mounting in a standard device box unless otherwise indicated on the Drawings.
- B. Strobe Lights (Strobes): Strobes shall be located as shown on the Drawings. Strobes indicated for use outdoors shall be mounted at the indicated elevation and listed for use in wet locations. Strobe lights shall flash in synchronization and shall have the following specifications:
 1. Voltage: Strobe lights shall operate on 24 VDC nominal.
 2. Maximum pulse duration: 2/10ths of one second.
 3. Mounting: Provide surface mounting devices suitable for mounting in a standard single gang device box unless otherwise indicated on the Drawings. Unless otherwise indicated on the Drawings, strobe lights shall be mounted at 6'-8" (2.3 M) Above Finished Floor (AFF) or 6" (15.3 Cm) Below Finished Ceiling (BFC), whichever is lower. Ceiling mounted devices are not permitted without specific location approvals by the owner.
 4. Strobe intensity and flash rate: Must meet minimum requirements of UL 1971. Provide synchronous strobe lights with specific intensity Candela (Cd) rating of 177 Cd in all locations unless indicated otherwise on the drawings.
- C. Audible/Visual Combination Devices: Shall be located as shown on the Drawings and shall comply with all applicable requirements for both Horn and Strobe Lights.

2.5 INITIATING DEVICES

- A. Non-Addressable Type Devices – General: Unless otherwise indicated on the Drawings all initiating devices shall be individually addressable. In some cases, the use of non-addressable devices with an addressable monitor type module installed in a conditioned space will be necessary. These areas shall be identified on the Drawing with the acceptable device type for the specific locations.
- B. Addressable Type Devices – General: Unless otherwise indicated on the Drawings all initiating devices shall be individually addressable. Addressable devices shall comply with the following general requirements:
 1. Address Setting: Addressable devices shall provide an address setting means inherent within the device. Devices, which are addressed by the FACP are also acceptable.
 2. Connections: Addressable devices shall be connected to a Signaling Line Circuit (SLC) with (2) two wires. Signaling Line Circuits shall originate at the FACP.
 3. Device Identification: Addressable devices shall store an internal specific identifying "type" code that the FACP shall use to identify the type of device.
 4. Temperature Ratings: Addressable devices shall not be utilized in unconditioned spaces where temperature and/or humidity ranges can exceed the manufactures recommended ratings of the electronic component circuitry for proper operation.
 5. Operational Indications: Addressable devices shall provide powered LED's. LED's shall flash under normal conditions, indicating that the device is operational and in regular communication with the FACP. LED's shall be placed into steady illumination by the FACP to indicate that an alarm or off normal condition has been detected. The flashing mode operation of the detector LED's shall be optional through the system field program. An output connection shall also be provided in the device base to connect an external/remote LED indication of an alarm or off normal condition in specific required locations.
 6. Device Mounting: Unless otherwise specified all devices shall provide the following mounting criteria:
 - a. All detectors shall be ceiling-mount type and shall include a separate twist-lock base with a tamper proof feature.

- b. All other addressable devices, remote LED indicators, remote test switches, and isolation modules shall be wall-mount type.
- 7. Test Means: Detectors shall provide a test means whereby they will simulate an alarm condition and report that condition to the FACP. Such a test may be initiated at the detector itself (by activating a magnetic switch), or initiated remotely through means of a test switch (either magnetically or key operated), or on command from the FACP when in the "test" mode of operation.
- C. Manual Stations (Pull Stations): Unless otherwise indicated on the Drawings all pull stations shall comply with the following additional requirements:
 - 1. All pull stations shall have a dual-action mechanism requiring two actions to initiate an alarm condition.
 - 2. All pull stations shall provide a clear visual indication when operated, and shall utilize a key type reset for restoral to normal operation. Pull stations that employ a glass break rod are not acceptable.
 - 3. Construction: Pull stations shall be constructed of Lexan or other material suitable to the installation environment with clearly visible operating instructions provided on the cover. The word FIRE shall appear on the front of the stations in raised letters, 1.75 inches or larger. Stations shall be suitable for surface mounting or semi flush mounting as shown on the plans.
- D. Smoke Detectors: Unless otherwise indicated on the Drawings all smoke detectors shall comply with the following additional requirements:
 - 1. All smoke/duct detectors shall be "intelligent" in that smoke detector sensitivity shall be set through the FACP and shall be capable of adjustment in the field through the field programming of the system. Sensitivity shall be capable of being automatically adjusted by the FACP program on a time of day basis. The FACP program must also be capable of automatically compensating for dust accumulation and other slow environmental changes that may affect performance of the smoke and/or duct detectors. The detectors shall be listed by UL as meeting the calibrated sensitivity test requirements of NFPA 72. Devices shall be capable of reporting obscuration levels and maintenance alerts when any smoke/duct detector approaches 80% of its alarm threshold due to gradual contamination.
 - 2. All detectors shall be the plug-in type with a separate base to facilitate testing and maintenance.
 - 3. All detector bases shall provide locking tabs for all models located within 12' of floor and shall provide skirts for the bases to create a finished appearance. Terminals in the fixed base accept the system wiring.
 - 4. Photoelectric Smoke Detectors: Photoelectric smoke detectors shall use the photoelectric (light scattering) principal to measure smoke density and shall, on command from the control panel, send data to the panel representing the analog level of smoke density. Unless otherwise indicated on the Drawings all smoke detectors shall be photoelectric type.
 - 5. Ionization Smoke Detectors: Ionization smoke detectors shall use the dual-chamber ionization principal to measure products of combustion and shall, on command from the control panel, send data to the panel representing the analog level of products of combustion. Ionization type smoke detectors are indicated on the Drawings by the designation ION adjacent to the smoke detector symbol.
- E. Non-Addressable Thermal Detectors (Heat): Unless otherwise indicated on the Drawings all heat detectors shall comply with the following additional requirements:
 - 1. Heat Detectors shall be rated at 200°F. (93.3°C.) and unless otherwise indicated on the Drawings shall have a rate-of-rise element rated at 15°F. (-9.4°C.) per minute.
 - 2. Heat detectors located outside conditioned spaces shall be UL listed for Outdoor Use.

2.6 MONITOR AND CONTROL DEVICES

- A. Addressable Dry Contact Monitor Modules: Addressable Monitor Modules shall be provided to connect (1) one non-addressable device or to supervise a non-addressable IDC zone (either Style D or Style B) of conventional type alarm initiating devices (any Normally Open [N.O.] dry contact device) to one of the Fire Alarm Control Panel Signaling Line Circuit Loops. Monitor modules shall be installed as required by the system configuration. All required monitor modules may not be shown on the Drawings.
1. Indication of Operation: Unless otherwise indicated on the Drawings an LED shall be provided that shall flash under normal conditions, indicating that the Monitor Module is operational and in regular communication with the FACP.
 2. Mounting Requirements: Monitor Modules shall be mounted in a standard 4-inch square, 2-1/8" deep electrical box at the same height requirement as Notification Appliance devices in a clearly visible location.
- B. Addressable Control Modules: Addressable Control Modules shall be provided to supervise and control the operation of (1) one conventional Notification Appliance Circuit (NAC) of compatible, 24 VDC powered, polarized Audio/Visual (A/V) Notification Appliances. For fan shutdown and other auxiliary control functions, the control module may be set to operate as a dry contract relay. The control module shall provide address-setting means using decimal switches and shall also store an internal identifying code that the control panel shall use to identify the type of device. An LED shall be provided that shall flash under normal conditions, indicating that the control module is operational and is in regular communication with the control panel. Control modules shall be rated for the load they control. (Inductive Loads require inductive rated modules.)
1. Mounting Requirements: Control Modules shall mount in a standard 4-inch square, 2-1/8" deep electrical box, and shall only be installed in conditioned spaces.
 2. Configuration: The control module NAC circuit may be wired for Style Y Class B with up to 1 Amp of inductive A/V signal, or 2 Amps of resistive A/V signal operation, or as a dry contact (Form C) relay. The control module shall be suitable for pilot duty applications and rated for a minimum of 0.6 amps at 30 VDC. The relay coil shall be magnetically latched to reduce wiring connection requirements, and to ensure that 100% of all auxiliary relay or NAC's may be energized at the same time on the same pair of wires.
 3. Power Source: Audio/visual power shall be provided by a separate supervised power loop from the main fire alarm control panel or from a supervised, UL listed remote power supply. A/V power sources and connections are not shown on the Drawings
 4. Test Switch: A magnetic test switch shall be provided to test the module without opening or shorting its NAC wiring.
- C. Isolator Modules: Isolator Modules shall be provided to automatically isolate wire-to-wire short circuits on an SLC loop. The Isolator Module shall limit the number of modules or detectors that may be rendered inoperative by a short circuit fault on the SLC Loop.
1. Operation: Isolator Modules shall operate such that if a wire-to-wire short occurs, the Isolator Module shall automatically open-circuit (disconnect) the SLC loop. When the short circuit condition is corrected, the Isolator Module shall automatically reconnect the isolated section. The Isolator Module shall not require any address setting, and its operations shall be totally automatic. It shall not be necessary to replace or reset an Isolator Module after its normal operation.
 2. Locations: Provide (2) Isolator Modules at the FACP for both ends of each SLC loop. Provide a minimum of one (1) Isolator Module in the field at the mid-point of the device loop. Provide additional modules necessary to limit the number of devices between isolators to 20.
 3. Mounting: The Isolator Module shall mount in standard 4-inch square, 2-1/8" deep electrical boxes, wall mounted at the same height as A/V devices in a clearly viewable area in corridors. It shall provide a single LED that shall flash to indicate

that the Isolator is operational and shall illuminate steadily to indicate that a short circuit condition has been detected and isolated.

2.7 MISCELLANEOUS SYSTEM ITEMS

- A. Remote Display Annunciators: The FACP should be located at the main entrance to the facility in concurrence and request of the Owner and the AHJ. On rare instances when the fire alarm panel cannot be placed at the main entrance, a remote annunciators shall be installed with the following capabilities:
1. Alphanumeric Display Annunciators: Shall be supervised and remotely located as specified on the Drawings.
 - a. Unit shall have a back-lit LCD display containing a minimum of (80) eighty characters for alarm annunciation in clear English text.
 - b. The LCD annunciator shall display all alarm, trouble, and supervisory conditions in the system and provide duplicate "active" manual switching functions of the FACP, including: Acknowledging, Signal Silencing, System Reset, and Test/Drill.
 - c. The annunciator shall be in a lockable cabinet keyed the same as the FACP.
 - d. Connections: The annunciator shall connect to a two-wire EIA-485 interface. The two-wire connection shall be capable operation at distances of 6,000 feet. Provide interface to fiber optic cable systems and/or repeater units where such are indicated on the Drawings.
 - e. System Capacity: The system shall allow a minimum of four LCD annunciators. In addition to annunciation functions, each LCD annunciator shall be capable of the following software programmed system functions: Acknowledge, Signal Silence and Reset.
 2. Serially Connected LED Annunciator: Annunciator shall communicate with the fire alarm control panel via an EIA-485 communications loop (four-wire) and shall individually annunciate all zones in the system. System zones shall be as indicated on the Drawings.
 - a. Annunciator Indicators: The annunciator shall provide a red Alarm LED per zone, yellow Trouble LED, and Supervisory Trouble LED per zone. The annunciator shall also have an "ON-LINE" LED, local piezo sounder, local acknowledge/lamp test switch, and custom zone/function identification labels. Annunciator switches may be used for System control such as, Global Acknowledge, Global Signal Silence, and Global System Reset. All annunciator switches and indicators shall be software programmable.
 - b. The annunciator shall be in a key lockable cabinet.
 3. LED Graphic Display Panel:
 - a. Annunciator Indicators: The annunciator shall provide a red Alarm LED per zone, yellow Trouble LED, and Supervisory Trouble LED per zone. The annunciator shall also have an "ON-LINE" LED, local piezo sounder, local acknowledge/lamp test switch, and custom zone/function identification labels. Annunciator switches may be used for System control such as, Global Acknowledge, Global Signal Silence, and Global System Reset. All annunciator switches and indicators shall be software programmable.
 - b. Framed under glass graphic shall provide a LED lamp zone matrix/grid displaying each type of initiating device (manual stations, smoke detectors, thermal detectors, elevator lobby detectors, water flow, and supervisory) for each floor contained in the facility. The Owner must approve the specific floor labeling prior to construction. Floor references may vary per facility (i.e. Ground Floor may be referred to as 1st Floor).
 - c. The annunciator shall be in a key lockable cabinet.

4. Remote Annunciator Indicator Light (RAIL): Remote annunciator indicator lights shall be provided in locations where indicated on the Drawings. In addition, RAIL's shall have the following features:
 - a. RAIL's shall be provided with a key type switch for testing of the annunciated device.
 - b. Voltage: RAIL's shall operate on 24 VDC nominal.
 - c. Mounting: Provide flush mounting devices suitable for mounting in a standard single gang device box unless otherwise indicated on the Drawings. They shall be mounted in the wall at the same height as A/V devices. Do not mount in ceiling tiles.
- B. Wire:
 1. Non-Power-Limited Circuits: Copper conductors with 600V rated, THHN/THWN, color coded insulation.
 - a. Low Voltage Circuits: STRANDED, #18 AWG, minimum.
 - b. Line Voltage Circuits: SOLID, #12 AWG, minimum.
 2. Power Limited Circuits: NFPA70, Types FPL, FPLR, or FPLP, as recommended by the manufacturer. Data Loop wire shall be shielded pair #18 AWG, 30 pf/ft capacitance or less, unless specifically prohibited by the manufacturer and stated on the wiring submittal.

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION

- A. Comply with NFPA 72 for installation of fire-alarm equipment.
- B. Equipment Mounting: Install fire-alarm control unit on finished floor with tops of cabinets not more than 72 inches (1830 mm) above the finished floor.
- C. Smoke- or Heat-Detector Spacing:
 1. HVAC: Locate detectors not closer than 3 feet (1 m) from air-supply diffuser or return-air opening.
 2. Lighting Fixtures: Locate detectors not closer than 12 inches (300 mm) from any part of a lighting fixture.
- D. Remote Status and Alarm Indicators: Install near each smoke detector and each sprinkler water-flow switch and valve-tamper switch that is not readily visible from normal viewing position.
- E. Audible Alarm-Indicating Devices: Install not less than 6 inches (150 mm) below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille.
- F. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 6 inches (150 mm) below the ceiling.
- G. Device Location-Indicating Lights: Locate in public space near the device they monitor.
- H. Fire-Alarm Control Unit: Surface mounted or semi-recessed as noted, with tops of cabinets not more than 72 inches (1830 mm) above the finished floor.

3.2 CONNECTIONS

- A. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 3 feet (1 m) from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.
 1. Supervisory connections at valve supervisory switches.
- B. Identify system components, wiring, cabling, and terminals.
- C. Install framed instructions in a location visible from fire-alarm control unit.

3.3 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.

3.4 EMERGENCY RESPONDER RADIO REPEATERS TESTING

- A. At the appropriate time the Division 28 contractor shall provide testing to determine whether a BDA (Bi-Directional Amplifier) system is required for the building. The technician shall be FCC certified to provide this testing. Test results shall be shared with the Owner and Design team as soon as possible. **TESTING SHALL BE PROVIDED AS PART OF THE BASE BID; ANY SYSTEM INSTALLATION WILL BE PROVIDED AS A CHANGE ORDER TO THE CONTRACT.**

3.5 FIELD QUALITY CONTROL

- A. Field tests shall be witnessed by authorities having jurisdiction
- B. Tests and Inspections:
 - 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 NFPA 72 in its "Completion Documents, Preparation" Table in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter.
 - 2. System Testing: Comply with "Test Methods" Table in the "Testing" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
 - 3. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
- C. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.
- D. Fire-alarm system will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.
- F. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.
- G. 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.

END OF SECTION 28 31 11

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SECTION 311001 - SITE GRUBBING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Removing designated trees, shrubs, and other plant life.

1.2 SUBMITTALS

- A. Section 013300 - Submittal Procedures: Requirements for submittals.
- B. Product Data: Submit data for herbicide. Indicate compliance with applicable codes for environmental protection.

1.3 QUALITY ASSURANCE

- A. Conform to applicable code for environmental requirements, disposal of debris, burning debris on site, and use of herbicides.
- B. Perform Work in accordance with of state transportation standards.
- C. Perform Work in accordance with State Department of Environmental Quality standards and approved National Pollutant Discharge Elimination System (NPDES) permit.

PART 2 - PRODUCTS – Not Used

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Section 013000 - Administrative Requirements: Verification of existing conditions before starting work.
- B. Verify existing plant life designated to remain is tagged or identified.
- C. Identify waste area for placing removed materials.

3.2 PREPARATION

- A. Call Local Utility Line Information service at 811 not less than three working days before performing Work.
 - 1. Request underground utilities to be located and marked within and surrounding construction areas.

3.3 PROTECTION

- A. Locate, identify, and protect from damage utilities indicated to remain.
- B. Protect trees, plant growth, and features designated to remain, as final landscaping as specified in Section 015000 - Temporary Facilities and Controls.
- C. Protect benchmarks, survey control points, and existing structures from damage or displacement.

3.4 CLEARING AND GRUBBING

- A. Clearing and grubbing shall consist of clearing the surface of the ground of the designated areas of all trees, stumps, down timber, logs, snags, brush, undergrowth, hedges, heavy growth of grass or weeds, fences, debris, and rubbish of any nature, natural obstructions or such material which in the opinion of the ENGINEER is unsuitable including the grubbing of stumps, roots, matted roots, and the disposal from the project of all spoil materials resulting from clearing and grubbing.
- B. In areas designated to be cleared and grubbed, all stumps, roots, buried logs, brush, grass, and other unsatisfactory materials as indicated on the plans, shall be removed. Tap roots and other projections over 1-1/2 inches in diameter shall be grubbed out to a depth of at least 18 inches below the finished subgrade or slope elevation.
- C. All holes remaining after the grubbing operation shall have the sides of the holes flattened to facilitate filling with acceptable material and compacting as required. The same procedure shall be applied to all holes remaining after grubbing in areas where the depth of holes exceeds the depth of the proposed excavation.

3.5 REMOVAL AND DISPOSAL

- A. CONTRACTOR shall coordinate in accordance with OWNER's agreement regarding any material that can be commercially salvaged.
- B. All materials removed by clearing or by clearing and grubbing shall be disposed of outside the project limits at the CONTRACTOR's responsibility, except when otherwise directed by the ENGINEER.
- C. Continuously clean-up and remove waste materials from site. Do not allow materials to accumulate on site.
- D. Do not burn or bury materials on site. Leave site in clean condition.

END OF SECTION 311000

SECTION 312213 - ROUGH GRADING**PART 1 - GENERAL****1.1 SUMMARY****A. Section Includes:**

1. Excavating topsoil.
2. Excavating subsoil.
3. Stockpiling materials.
4. Cutting, grading, filling, rough contouring, and compacting, site.

1.2 REFERENCES**A. ASTM International:**

1. ASTM C136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
2. ASTM D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³ (600 kN-m/m³).
3. ASTM D1556 - Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.
4. ASTM D2419 - Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate.
5. ASTM D2434 - Standard Test Method for Permeability of Granular Soils (Constant Head).
6. ASTM D3017 - Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).

1.3 SUBMITTALS**A. Section 013300 - Submittal Procedures: Requirements for submittals.****B. Material Test Reports: For each on-site and borrow soil material proposed for use as follows:**

1. Classification according to ASTM D2487.
2. Laboratory compaction curve according to ASTM D698.
3. Submit test results within 24-hours after testing is completed.

C. Materials Source: Obtain materials from same source throughout.**D. Geotechnical Testing Agency Qualifications: Qualified according to ASTM E329 and ASTM D3740 for testing indicated.****1.4 CLOSEOUT SUBMITTALS****A. Section 017000 - Execution and Closeout Requirements: Requirements for submittals.**

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

1.5 QUALITY ASSURANCE

- A. Perform Work in accordance with ASTM C136, ASTM D2419, and ASTM D2434.
- B. Perform Work in accordance with authorities having jurisdiction requirements.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.
- B. Fill and Backfill: Where suitable, use existing onsite excavated satisfactory soils free from rubbish, debris, organic material, frozen material, or other objectionable materials.
- C. Topsoil: Top 6 inches of existing onsite soil.
- D. Satisfactory Soils: Soil Classification Groups CL, ML, GW, GP, GM, GC, SW, SP, SM, or SC according to ASTM D2487, or a combination of these groups meeting the requirements of the Geotechnical Report; free of rock or gravel larger than 3 inches in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter.
- E. Unsatisfactory Soils: Soil Classification Groups OL, CH, MH, OH, and PT according to ASTM D2487, or combination of these groups. Unsatisfactory soils also include satisfactory soils not meeting the minimum requirements according to the Geotechnical Report.
- F. Subbase Material: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D2940; with at least 90 percent passing 1-1/2-inch sieve and not more than 12 percent passing No. 200 sieve.
- G. Base Course: In accordance with Section 32 11 23.
- H. Engineered Fill: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D2940; with at least 90 percent passing 1-1/2-inch sieve and not more than 12 percent passing No. 200 sieve.
- I. Drainage Course: Narrowly graded mixture of washed crushed stone or crushed or uncrushed gravel; ASTM D448; coarse-aggregate grading Size 57; with 100 percent passing 1-1/2-inch sieve and zero to 5 percent passing No. 8 sieve.
- J. Filter Material: Narrowly graded mixture of natural or crushed gravel, or crushed stone and natural sand; ASTM D448; coarse-aggregate grading Size 67; with 100 percent passing 1-inch sieve and zero to 5 percent passing No. 4 sieve.
- K. Sand: ASTM C33; fine aggregate.
- L. Impervious Fill: Clayey gravel and sand mixture capable of compacting to dense state.

PART 3 - EXECUTION**3.1 EXAMINATION**

- A. Section 013000 - Administrative Requirements: Verification of existing conditions before starting work.
- B. Verify site conditions and report any deviations from the plan drawings to the ENGINEER within 48 hours of discovery.
- C. Verify survey benchmark and intended elevations for the Work are as indicated on Drawings.

3.2 PREPARATION

- A. Call Local Utility Line Information service at 811 not less than three working days before performing Work.
 - 1. Request underground utilities to be located and marked within and surrounding construction areas.
- B. Identify required lines, levels, contours, and datum.
- C. Notify utility company to remove and/or relocate utilities as indicated on the plan drawings.
- D. Protect utilities indicated to remain from damage.
- E. Protect plant life, lawns, and other features remaining as portion of final landscaping.
- F. Protect benchmarks, survey control point, existing structures, fences, sidewalks, paving, and curbs from excavating equipment and vehicular traffic.

3.3 TOPSOIL EXCAVATION

- A. Excavate topsoil from areas to be further excavated, relandscaped, or regraded, and as indicated on the plan drawings, without mixing with foreign materials for use in finish grading.
- B. Do not excavate wet topsoil.
- C. Stockpile in areas designated on site and in accordance with §3.5 below. Stockpile material until reuse or removal/disposal.
- D. Remove excess topsoil not intended for reuse, from site.

3.4 SUBSOIL EXCAVATION

- A. Excavate subsoil from areas to be further excavated, relandscaped, or regraded.
- B. Do not excavate wet subsoil.
- C. When excavating through roots, perform Work by hand and cut roots with sharp axe.

- D. Remove excess subsoil not intended for reuse, from site.
- E. Stability: Replace damaged or displaced subsoil as specified for fill.

3.5 STOCKPILING

- A. Stockpile excavated material meeting requirements for subsoil and/or topsoil materials.
- B. Stockpile materials on Site at locations as indicated or designated by ENGINEER.
- C. Stockpile in sufficient quantities to meet Project schedule and requirements.
- D. Separate differing materials with dividers or stockpile apart to prevent intermixing of soil types or contamination.
- E. Stockpile in areas designated on site to depth not exceeding 35 feet and protect from erosion. Stockpile material until reuse or removal/disposal.
- F. Direct surface water away from stockpile to prevent erosion or deterioration of materials.
- G. Stockpile hazardous materials on impervious material and cover to prevent erosion and leaching until they are disposed.

3.6 FILLING

- A. Fill areas to contours and elevations with unfrozen materials.
- B. Place material in continuous layers as follows:
 - 1. Subsoil Fill: Maximum 8 inches compacted depth.
 - 2. Structural Fill: Maximum 8 inches compacted depth.
 - 3. Granular Fill: Maximum as indicated on the Plan Drawings.
- C. Maintain optimum moisture content of fill materials to attain required compaction density.
- D. Slope grade away from building minimum 5 percent slope for minimum distance of 10 ft, unless noted otherwise.
- E. Make grade changes gradual. Blend slope into level areas.
- F. Repair or replace items indicated to remain that were damaged by excavation or filling. Repair and replacement shall be at CONTRACTOR's expense and to the satisfaction of the OWNER and ENGINEER.
- G. Install Work in accordance with authorities having jurisdiction standards.

3.7 TOLERANCES

- A. Section 014000 - Quality Requirements: Tolerances.
- B. Top Surface of Subgrade: Plus or minus 1/10-foot from required elevation.

3.8 FIELD QUALITY CONTROL TESTING AND ACCEPTANCE

- A. Section 014000 - Quality Requirements and 017000 - Execution and Closeout Requirements: Field inspecting, testing, adjusting, and balancing.
- B. Perform laboratory material tests in accordance with ASTM D698 or Geotechnical Engineer's recommendations. Geotechnical Engineer's recommendation shall govern testing requirements.
- C. Perform in place compaction tests in accordance with the following:
 - 1. Density Tests: In accordance ASTM D1556, ASTM D6938 or Geotechnical Engineer's recommendations. Geotechnical Engineer's recommendation shall govern testing requirements. or.
 - 2. Moisture Tests: ASTM D3017.
- D. When tests indicate Work does not meet specified requirements, remove Work, replace, and retest.
- E. Frequency of Tests:
 - 1. Under Structures, Building Slabs, Steps, and Pavements: At least one test per 1,000 square feet or less, but no fewer than three tests.
 - 2. Under Walkways: At least one test per 1,000 square feet or less, but no fewer than three tests.
 - 3. Under Turf or Unpaved Areas: Random tests, as necessary.
 - 4. In accordance with Geotechnical Engineer's recommendations. Geotechnical Engineer's recommendation shall govern frequency of testing.
- F. Test Acceptance
 - 1. Backfill and Fill Acceptance:
 - a. Under Structures, Building Slabs, Steps, and Pavements: 100 percent of maximum laboratory density.
 - b. Under Walkways: 95 percent of maximum laboratory density.
 - c. Under Turf or Unpaved Areas: 90 percent of maximum laboratory density.
 - 2. Filter Material Acceptance: 95 percent of maximum laboratory density.
 - 3. Subbase Course Acceptance: 100 percent of maximum laboratory density.
 - 4. Drainage Course Acceptance: 100 percent of maximum laboratory density.
 - 5. If tests indicate Work is not acceptable, re-compact and retest. If necessary, remove and replace Work.

END OF SECTION 312213

SECTION 312316 - EXCAVATION**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes:
 - 1. Soil densification.
 - 2. Excavating for building foundations.
 - 3. Excavating for paving, roads, and parking areas.
 - 4. Excavating for slabs on grade.
 - 5. Excavating for Site structures.
 - 6. Excavating for landscaping.

1.2 DEFINITIONS

- A. Backfill: Soil material or flowable fill used to fill an excavation after placement of bedding course, utility, and embedment material.
- B. Initial Backfill: Backfill placed beside and over pipe in trench, including haunches to support sides of pipe.
- C. Final Backfill: Backfill placed over initial backfill to fill trench.
- D. Bedding Course: Aggregate layer placed over excavated subgrade in trench before laying pipe.
- E. Borrow Soil: Satisfactory soil imported from off-site for use as backfill.
- F. Rock: Rock material in beds, ledges, unstratified masses, conglomerate deposits, and boulders of rock material that exceed 1-cubic yard for bulk excavation or $\frac{3}{4}$ -cubic yard for footing, trench, and pit excavation that cannot be removed by rock-excavating equipment equivalent to following in size and performance ratings, without systematic drilling, ram hammering, ripping, or blasting, when permitted.
- G. Equipment for Footing, Trench, and Pit Excavation: Late-model, track-mounted hydraulic excavator; equipped with 42-inch maximum-width, short-tip-radius rock bucket; rated at not less than 138-horsepower flywheel power with bucket-curling force of not less than 28,700-pound-foot and stick-crowd force of not less than 18,400-pound-foot with extra-long reach boom. Ratings are based on Caterpillar's Model No. 320CL or Model No. 320DL.
- H. Equipment for Bulk Excavation: Late-model, track-mounted loader; rated at not less than 230-horsepower flywheel power and developing minimum of 47,992-pound-foot breakout force with general-purpose bare bucket. Ratings are based on Caterpillar's Model No. 973C.
- I. Soil Classification: ASTM D2487.
- J. Subgrade: Uppermost surface of excavation or top surface of fill or backfill immediately below subbase, drainage fill, drainage course, or topsoil materials.

- K. Utility: Any buried pipe, duct, conduit, cable, underground service to buildings, and associated appurtenances.

1.3 SUBMITTALS

- A. Shop Drawings:
 - 1. Indicate soil densification grid for each size and configuration footing requiring soil densification.
 - 2. Excavation Protection Plan:
 - a. Describe sheeting, shoring, and bracing materials and installation, as required, to protect excavations and adjacent structures and property.
 - b. Submit signed and sealed Shop Drawings with design calculations and assumptions to support plan.
- B. Field Quality-Control Submittals: Indicate results of CONTRACTOR-furnished tests and inspections.
- C. Qualifications Statement: For licensed professional.

1.4 QUALITY ASSURANCE

- A. Licensed Professionals Qualifications: Professional Engineer experienced in design of specified Work and licensed in the state of which the work is commencing.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Perform Work according with authorities having jurisdiction.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Utility Service Locator:
 - 1. Call local utility service-line information at 811 not less than three working days before performing Work.
 - 2. Request that underground utilities be located and marked within and immediately surrounding construction areas.
 - 3. Identify required lines, levels, contours, and data.
- B. Existing Utilities:
 - 1. Notify utility company to remove and/or relocate utilities as indicated on the plan drawings.
 - 2. Protect from damage utilities indicated to remain.

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- C. Protect plant life, lawns, and other features designated to remain as portion of final landscaping.
- D. Protect benchmarks, survey control points, existing structures, fences, sidewalks, paving, and curbs from excavating equipment and vehicular traffic.
- E. Do not close or obstruct roadways, sidewalks, or hydrants without appropriate permits from authorities having jurisdiction.
- F. Erect and maintain temporary barriers and security devices at indicated locations, including warning signs, warning lights, and similar measures, for protection of public, OWNER, and existing improvements indicated to remain.

3.2 TOLERANCES

- A. Maximum Deviation from Center of Completed Compaction: 8 inches from indicated position.
- B. Maximum Deviation from Vertical: 4 degrees during vibrator insertion.

3.3 EXCAVATION

- A. Underpin adjacent structures which may be damaged by excavation Work.
- B. Excavate subsoil to accommodate building foundations, slabs on grade, paving, Site structures, bridge abutments, and construction operations.
- C. Excavate to working elevation for piling Work.
- D. Compact disturbed load-bearing soil in direct contact with foundations to original bearing capacity, as specified in Section 312323 "Fill" and Section 312316.13 "Trenching".
- E. Slope banks with machine to angle of repose or less until shored.
- F. Do not interfere with 45-degree bearing splay of foundations.
- G. Grade top perimeter of excavation to prevent surface water from draining into excavation.
- H. Trim excavation and remove loose matter.
- I. Removal of Deleterious Materials:
 - 1. Remove excess and unsuitable material from Site.
- J. Notify ENGINEER of unexpected subsurface conditions.
- K. Correct over-excavated areas as directed by ENGINEER.
- L. Stockpiling:
 - 1. Stockpile excavated material meeting requirements for subsoil and/or topsoil materials.
 - 2. Stockpile materials on Site at locations as indicated or designated by ENGINEER.
 - 3. Stockpile in sufficient quantities to meet Project schedule and requirements.
 - 4. Separate differing materials with dividers or stockpile apart to prevent intermixing of soil types or contamination.
 - 5. Stockpile maximum height shall be 35 feet.
 - 6. Direct surface water away from stockpile to prevent erosion or deterioration of materials.

7. Stockpile hazardous materials on impervious material and cover to prevent erosion and leaching until they are disposed.

- M. Repair or replace items indicated to remain that have been damaged by excavation.

3.4 FIELD QUALITY CONTROL

- A. Tests and Inspections:

1. Request visual inspection of bearing surfaces by ENGINEER and inspection agency 3 days before installing subsequent Work.

3.5 PROTECTION

- A. Prevent displacement or loose soil from falling into excavation and maintain soil stability.
- B. Protect bottom of excavations and soil adjacent to and beneath foundation from freezing.
- C. Protect structures, utilities, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards that may be created by earth operations.

END OF SECTION 312316

SECTION 312316.13 - TRENCHING**PART 1 - GENERAL****1.1 SUMMARY****A. Section Includes:**

1. Excavating trenches for utilities from 5 feet outside building to utility service.
2. Backfilling and compaction.

1.2 REFERENCES**A. ASTM International:**

1. ASTM D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³).
2. ASTM D1556 - Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.
3. ASTM D2922 - Standard Test Method for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
4. ASTM D3017 - Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).

1.3 DEFINITIONS

- A. Backfill: Soil material or flowable fill used to fill an excavation after placement of bedding course, utility, and embedment material.
- B. Initial Backfill: Backfill placed beside and over pipe in trench, including haunches to support sides of pipe.
- C. Final Backfill: Backfill placed over initial backfill to fill trench.
- D. Bedding Course: Aggregate layer placed over excavated subgrade in trench before laying pipe.
- E. Borrow Soil: Satisfactory soil imported from off-site for use as backfill.
- F. Rock: Rock material in beds, ledges, unstratified masses, conglomerate deposits, and boulders of rock material that exceed 1-cubic yard for bulk excavation or $\frac{3}{4}$ -cubic yard for footing, trench, and pit excavation that cannot be removed by rock-excavating equipment equivalent to following in size and performance ratings, without systematic drilling, ram hammering, ripping, or blasting, when permitted:
- G. Equipment for Footing, Trench, and Pit Excavation: Late-model, track-mounted hydraulic excavator; equipped with 42-inch maximum-width, short-tip-radius rock bucket; rated at not less than 138-horsepower flywheel power with bucket-curling force of not less than 28,700-pound-foot and stick-crowd force of not less than 18,400-pound-foot with extra-long reach boom. Ratings are based on Caterpillar's Model No. 320CL or Model No. 320DL.

- H. Equipment for Bulk Excavation: Late-model, track-mounted loader; rated at not less than 230-horsepower flywheel power and developing minimum of 47,992-pound-foot breakout force with general-purpose bare bucket. Ratings are based on Caterpillar's Model No. 973C.
- I. Soil Classification: ASTM D2487.
- J. Subgrade: Uppermost surface of excavation or top surface of fill or backfill immediately below subbase, drainage fill, drainage course, or topsoil materials.
- K. Utility: Any buried pipe, duct, conduit, cable, underground service to buildings, and associated appurtenances.

1.4 SUBMITTALS

- A. Section 013300 - Submittal Procedures: Requirements for submittals.
- B. Product Data: Submit manufacturer's product data for marker tape.
- C. Material Test Reports: For each on-site and borrow soil material proposed for bedding, embedment, and backfill as follows:
 - 1. Classification according to ASTM D2487.
 - 2. Laboratory compaction curve according to ASTM D698.
 - 3. Submit test results within 24-hours after testing is completed.
- D. Materials Source: Obtain materials from same source throughout. .

1.5 QUALITY ASSURANCE

- A. Perform Work in accordance with authorities having jurisdiction.

1.6 QUALIFICATIONS

- A. If required, prepare excavation protection plan under direct supervision of Professional Engineer experienced in design of this Work and licensed in State of North Carolina.

1.7 FIELD MEASUREMENTS

- A. Verify field measurements prior to fabrication.

1.8 COORDINATION

- A. Section 013000 - Administrative Requirements: Coordination and project conditions.
- B. Verify Work associated with lower elevation utilities is complete before placing higher elevation utilities.

PART 2 - PRODUCTS**2.1 MATERIALS**

- A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.
- B. Fill and Backfill: Where suitable, use existing onsite excavated satisfactory soils free from rubbish, debris, organic material, frozen material, or other objectionable materials.
- C. Topsoil: Top 6 inches of existing onsite soil.
- D. Satisfactory Soils: Soil Classification Groups CL, ML, GW, GP, GM, GC, SW, SP, SM, or SC according to ASTM D2487, or a combination of these groups meeting the requirements of the Geotechnical Report; free of rock or gravel larger than 3 inches in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter.
- E. Unsatisfactory Soils: Soil Classification Groups OL, CH, MH, OH, and PT according to ASTM D2487, or combination of these groups. Unsatisfactory soils also include satisfactory soils not meeting the minimum requirements according to the Geotechnical Report.
- F. Subbase Material: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D2940; with at least 90 percent passing 1-1/2-inch sieve and not more than 12 percent passing No. 200 sieve.
- G. Base Course: In accordance with Section 32 11 23.
- H. Engineered Fill: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D2940; with at least 90 percent passing 1-1/2-inch sieve and not more than 12 percent passing No. 200 sieve.
- I. Drainage Course: Narrowly graded mixture of washed crushed stone or crushed or uncrushed gravel; ASTM D448; coarse-aggregate grading Size 57; with 100 percent passing 1-1/2-inch sieve and zero to 5 percent passing No. 8 sieve.
- J. Filter Material: Narrowly graded mixture of natural or crushed gravel, or crushed stone and natural sand; ASTM D448; coarse-aggregate grading Size 67; with 100 percent passing 1-inch sieve and zero to 5 percent passing No. 4 sieve.
- K. Sand: ASTM C33; fine aggregate.
- L. Impervious Fill: Clayey gravel and sand mixture capable of compacting to dense state.

PART 3 - EXECUTION**3.1 LINES AND GRADES**

- A. Lay pipes to lines and grades indicated on Drawings.
 - 1. ENGINEER and OWNER reserve right to make changes in lines, grades, and depths of utilities when changes are required for Project conditions.

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- B. Use laser-beam instrument with qualified operator to establish lines and grades.

3.2 PREPARATION

- A. Call Local Utility Line Information service at 811 not less than three working days before performing Work.
 - 1. Request underground utilities to be located and marked within and surrounding construction areas.
- B. Identify required lines, levels, contours, and datum locations.
- C. Protect plant life, lawns, and other features remaining as portion of final landscaping.
- D. Protect benchmarks, existing structures, fences, sidewalks, paving, and curbs from excavating equipment and vehicular traffic.
- E. Maintain and protect above and below grade utilities indicated to remain.
- F. Establish temporary traffic control and detours when trenching is performed in public right-of-way. Relocate controls and reroute traffic as required during progress of Work.

3.3 TRENCHING

- A. Excavate subsoil required for utility installation.
- B. Remove lumped subsoil, boulders, and rock.
- C. Perform excavation within 24 inches of existing utility service in accordance with utility's requirements.
- D. Do not advance open trench more than 60 feet ahead of installed pipe.
- E. Cut trenches to width indicated on Drawings. Remove water or materials that interfere with Work.
- F. Excavate trenches to depth indicated on Drawings. Provide uniform and continuous bearing and support for bedding material and utilities.
- G. Do not interfere with 45 degree bearing splay of foundations.
- H. When Project conditions permit, slope side walls of excavation starting 2 feet above top of pipe. When side walls cannot be sloped, provide sheeting and shoring to protect excavation as specified in this section.
- I. When subsurface materials at bottom of trench are loose or soft, excavate to greater depth as directed by ENGINEER until suitable material is encountered.
- J. Cut out soft areas of subgrade not capable of compaction in place. Backfill with Fill Type as directed by ENGINEER and compact to density equal to or greater than requirements for subsequent backfill material.

- K. Trim excavation. Hand trim for bell and spigot pipe joints. Remove loose matter.
- L. Correct areas over excavated areas with compacted backfill as specified for authorized excavation or replace with fill concrete as directed by ENGINEER.
- M. Remove excess subsoil not intended for reuse, from site.

3.4 SHEETING AND SHORING

- A. Sheet, shore, and brace excavations to prevent danger to persons, structures, and adjacent properties and to prevent caving, erosion, and loss of surrounding subsoil.
- B. Support trenches in accordance with authorities having jurisdiction and OSHA standards.
- C. Repair damage caused by failure of the sheeting, shoring, or bracing and for settlement of filled excavations or adjacent soil.
- D. Repair damage to new and existing Work from settlement, water or earth pressure or other causes resulting from inadequate sheeting, shoring, or bracing. Repair shall be at no additional cost to the OWNER.

3.5 BACKFILLING

- A. Backfill trenches to contours and elevations with unfrozen fill materials.
- B. Systematically backfill to allow maximum time for natural settlement. Do not backfill over porous, wet, frozen, or spongy subgrade surfaces.
- C. Place geotextile fabric as indicated on the Plan Drawings.
- D. Place material in continuous layers as follows:
 - 1. Subsoil Fill: Maximum 8 inches compacted depth.
 - 2. Structural Fill: Maximum 6 inches compacted depth.
 - 3. Granular Fill: Maximum as indicated on Plan Drawings.
- E. Employ placement method that does not disturb or damage foundation perimeter drainage or utilities in trench.
- F. Maintain optimum moisture content of fill materials to attain required compaction density.
- G. Do not leave more than 50 feet of trench open at end of working day.
- H. Protect open trench to prevent danger to OWNER and the public.

3.6 TOLERANCES

- A. Section 014000 - Quality Requirements: Tolerances.
- B. Top Surface of Backfilling Under Paved Areas: Plus or minus 0.5 inch from required elevations.

- C. Top Surface of General Backfilling: Plus or minus 1 inch from required elevations.

3.7 FIELD QUALITY CONTROL

- A. Section 014000 - Quality Requirements and 017000 - Execution and Closeout Requirements: Field inspecting, testing, adjusting, and balancing.
- B. Perform laboratory material tests in accordance with ASTM D698. Geotechnical Engineer's report shall govern testing requirements.
- C. Perform in place compaction tests in accordance with the following:
 - 1. Density Tests: ASTM D1556 or ASTM D2922.
 - 2. Moisture Tests: ASTM D3017.
- D. Frequency and Acceptance of Tests:
 - 1. Frequency: At each compacted initial and final backfill layer, take at least one test for every 100-feet or less of trench length, but no fewer than two tests per 100-feet of trench.
 - 2. Acceptance: Compact bedding, embedment and backfill materials to minimum of 95 percent of maximum laboratory density regardless of material.
 - 3. When tests indicate Work does not meet specified requirements, remove Work, replace, compact, and retest.

3.8 PROTECTION OF FINISHED WORK

- A. Section 017000 - Execution and Closeout Requirements: Protecting finished work.
- B. Reshape and re-compact fills subjected to vehicular traffic during construction.

END OF SECTION 312316.13

SECTION 312323 - FILL**PART 1 - GENERAL****1.1 SUMMARY****A. Section Includes:**

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

1.2 REFERENCE STANDARDS**A. ASTM International:**

1. ASTM D698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³).
2. ASTM D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft³).
3. ASTM D6031/D6031M - Standard Test Method for Logging In Situ Moisture Content and Density of Soil and Rock by the Nuclear Method in Horizontal, Slanted, and Vertical Access Tubes.
4. ASTM D6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

1.3 SUBMITTALS

- A. Section 013300 - Submittal Procedures: Requirements for submittals.
- B. Product Data: Submit manufacturer information for geotextile fabric, indicating fabric and construction.
- C. Material Test Reports: For each on-site and borrow soil material proposed for use as follows:
 1. Classification according to ASTM D2487.
 2. Laboratory compaction curve according to ASTM D698.
 3. Submit test results within 24-hours after testing is completed.
- D. Materials Source: Obtain materials from same source throughout.
- E. Geotechnical Testing Agency Qualifications: Qualified according to ASTM E329 and ASTM D3740 for testing indicated.
- F. Field Quality-Control Submittals: Indicate results of CONTRACTOR-furnished tests and inspections.

1.4 QUALITY ASSURANCE

- A. Perform Work according to authorities having jurisdiction standards.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.
- B. Fill and Backfill: Where suitable, use existing onsite excavated satisfactory soils free from rubbish, debris, organic material, frozen material, or other objectionable materials.
- C. Topsoil: Top 6 inches of existing onsite soil.
- D. Satisfactory Soils: Soil Classification Groups CL, ML, GW, GP, GM, GC, SW, SP, SM, or SC according to ASTM D2487, or a combination of these groups meeting the requirements of the Geotechnical Report; free of rock or gravel larger than 3 inches in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter.
- E. Unsatisfactory Soils: Soil Classification Groups OL, CH, MH, OH, and PT according to ASTM D2487, or combination of these groups. Unsatisfactory soils also include satisfactory soils not meeting the minimum requirements according to the Geotechnical Report.
- F. Subbase Material: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D2940; with at least 90 percent passing 1-1/2-inch sieve and not more than 12 percent passing No. 200 sieve.
- G. Base Course: In accordance with Section 32 11 23.
- H. Engineered Fill: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D2940; with at least 90 percent passing 1-1/2-inch sieve and not more than 12 percent passing No. 200 sieve.
- I. Drainage Course: Narrowly graded mixture of washed crushed stone or crushed or uncrushed gravel; ASTM D448; coarse-aggregate grading Size 57; with 100 percent passing 1-1/2-inch sieve and zero to 5 percent passing No. 8 sieve.
- J. Filter Material: Narrowly graded mixture of natural or crushed gravel, or crushed stone and natural sand; ASTM D448; coarse-aggregate grading Size 67; with 100 percent passing 1-inch sieve and zero to 5 percent passing No. 4 sieve.
- K. Sand: ASTM C33; fine aggregate.
- L. Impervious Fill: Clayey gravel and sand mixture capable of compacting to dense state.

2.2 ACCESSORIES

- A. Geotextile Fabric: As specified in Section 310519.13 - Geotextiles for Earthwork.

PART 3 - EXECUTION**3.1 EXAMINATION**

- A. Section 017000 - Execution and Closeout Requirements: Requirements for installation examination.
- B. Verify that subdrainage, dampproofing, and waterproofing installations have been inspected.
- C. Verify that underground tanks are anchored to their own foundations to avoid flotation after backfilling.
- D. Verify structural integrity of unsupported walls to support loads imposed by fill.

3.2 PREPARATION

- A. Section 017000 - Execution and Closeout Requirements: Requirements for installation preparation.
- B. Compact subgrade to specified density requirements for subsequent backfill materials.
- C. Soft Subgrade:
 - 1. Cut out soft areas of subgrade not capable of compaction in place.
 - 2. Backfill with structural or granular fill, as directed by ENGINEER, and compact to density equal to or greater than specified requirements for subsequent fill material.
- D. Scarify subgrade surface to depth of 8 inches.

3.3 BACKFILLING

- A. Backfill areas to contours and elevations.
- B. Systematically backfill to allow maximum time for natural settlement.
- C. Do not backfill over porous, wet, frozen, or spongy subgrade surfaces, and do not backfill with frozen materials.
- D. Geotextile: Place geotextile fabric as indicated on the Plan Drawings.
- E. Maximum Compacted Depths:
 - 1. Place material in continuous layers to following depths:
 - a. Subsoil Fill: 8 inches.
 - b. Structural Fill: 6 inches.
 - c. Granular Fill: Maximum as indicated on the Plan Drawings.
- F. Use placement method that does not disturb or damage utilities in trench.
- G. Maintain optimum moisture content of fill materials to attain required compaction density.

H. Structures:

1. Backfill against supported foundation walls.
2. Backfill simultaneously on each side of unsupported foundation walls and vaults until supports are in place.
3. Slope grade away from building minimum 5 percent slope for minimum distance of 10 feet, unless otherwise noted otherwise.

I. Make gradual grade changes and blend slope into level areas.

J. Remove surplus backfill materials from Site.

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

3.4 TOLERANCES

A. Section 014000 - Quality Requirements: Requirements for tolerances.

B. Top Surface of Turf, Unpaved Areas, General Fill, and Backfill: Plus, or minus 0.08-foot from required elevation.

C. Walks and Pavements: Plus, or minus 0.04-foot from required elevation.

D. Top Surface of Subgrade: Plus, or minus 0.04-foot from required elevation.

E. Grading Inside Building Lines: Plus, or minus 0.50-inch with 10-foot straight edge.

F. Moisture Content: Plus, or minus 3-percent of optimum, or plus, or minus 5-percent as noted in the Geotechnical Report. Test in accordance with ASTM D6938.

3.5 FIELD QUALITY CONTROL TESTING AND ACCEPTANCE

A. Section 014000 - Quality Requirements: Requirements for inspecting and testing.

B. Section 017000 - Execution and Closeout Requirements: Requirements for testing, adjusting, and balancing.

C. Inspecting: Request visual inspection of bearing surfaces by inspection agency 2 days before installing subsequent Work.

D. Testing:

1. Laboratory Material Testing: Comply with ASTM D698 and/or ASTM D1557 as noted. Geotechnical Engineer's recommendation shall govern testing requirements.
2. In-Place Compaction Testing:
 - a. Density Tests: Comply with ASTM D6938.
 - b. Moisture Tests: Comply with ASTM D6031/D6031M.
3. If tests indicate that Work does not meet specified requirements, remove Work, replace, compact, and retest.
4. Testing Frequency:

- a. Under Structures, Building Slabs, Steps, and Pavements: At least one test per 1,000 square feet or less, but no fewer than three tests.
 - b. Under Walkways: At least one test per 1,000 square feet or less, but no fewer than three tests.
 - c. Under Turf or Unpaved Areas: Random tests, as necessary.
 - d. In accordance with Geotechnical Engineer's recommendations. Geotechnical Engineer's recommendation shall govern frequency of testing.
5. Test Acceptance. Compaction testing shall be in accordance with ASTM D698 unless otherwise noted.
- a. Backfill and Fill Acceptance:
 - 1) Under Structures, Building Slabs, Steps, and Pavements: 98 percent of maximum laboratory density, in upper one foot of structural fill in accordance with ASTM D698.
 - 2) Under Walkways: 95 percent of maximum laboratory density.
 - 3) Under Turf or Unpaved Areas: 90 percent of maximum laboratory density.
 - b. Filter Material Acceptance: 95 percent of maximum laboratory density.
 - c. Subbase Course Acceptance: 100 percent of maximum laboratory density.
 - d. Drainage Course Acceptance: 100 percent of maximum laboratory density
 - e. If tests indicate Work is not acceptable, re-compact and retest. If necessary, remove and replace Work.
6. Proof-roll compacted fill surfaces under slabs on grade, pavers, paving, and as directed by ENGINEER.

3.6 PROTECTION

- A. Section 017000 - Execution and Closeout Requirements: Requirements for protecting finished Work.
- B. Reshape and recompact fills subjected to vehicular traffic during construction.

END OF SECTION 312323

SECTION 312500 - EROSION AND SEDIMENTATION CONTROLS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Diversion channels.
 - 2. Rock energy dissipator.
 - 3. Rock apron.
 - 4. Sediment ponds.
 - 5. Sediment traps.

1.2 REFERENCES

- A. North Carolina Department of Transportation (NCDOT):
 - 1. NCDOT Standard Specifications for Roads and Structures (NCDOT Specifications):
- B. NCDOT Asphalt Quality Management System, Materials and Tests Unit, Asphalt QMS Manual (QMS Manual), latest edition.
- C. North Carolina Department of Environmental Quality (NCDEQ)

1.3 SUBMITTALS

- A. Section 013300 - Submittal Procedures: Requirements for submittals.
- B. Product Data: Product Data: Submit data on geotextile.
- C. Submit proposed mix design of each class of concrete for review prior to commencement of Work.
- D. Test Reports: Indicate certified tests results for precast concrete at manufacturing facility, cast-in-place concrete in field, and granular backfill.
- E. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

1.4 CLOSEOUT SUBMITTALS

- A. Section 017000 - Execution and Closeout Requirements: Requirements for submittals.

1.5 QUALITY ASSURANCE

- A. Perform Work according to North Carolina Department of Environmental Quality (NCDEQ), Department of Energy, Mineral, and Land Resources (DEMLR), and any additional authorities that may have jurisdiction standards.

- B. Install and maintain erosion control devices as required to function properly and to satisfy the representatives of the NCDEQ, DEMLR, local authorities having jurisdiction, and the ENGINEER.
 - 1. Any time delays experienced due to a shutdown by the NCDEQ, other authorities having jurisdiction, or due to unanticipated corrective work will not receive any time extensions on the contract.
 - 2. The CONTRACTOR is responsible for installing all devices necessary to control runoff from the site, regardless of any conditions of the permit or design by the ENGINEER.

1.6 PREINSTALLATION MEETINGS

- A. Section 013000 - Administrative Requirements: Pre-installation meeting.
- B. Conduct a pre-installation meeting in accordance with the approved permit and local jurisdictional requirements, as applicable.

1.7 ENVIRONMENTAL REQUIREMENTS

- A. Section 016000 - Product Requirements: Environmental conditions affecting products on site.
- B. Do not place grout when air temperature is below freezing.
- C. Do not place concrete when base surface temperature is less than 40 degrees F, or surface is wet or frozen.

PART 2 - PRODUCTS

2.1 ROCK AND GEOTEXTILE MATERIALS

- A. Furnish materials according to NCDEQ and NCDOT standards.
- B. Rock: irregular shaped rock; solid and nonfriable; of type and size indicated on Drawings.
- C. Geotextile Fabric: Furnish according to NCDEQ and NCDOT standards.

2.2 CONCRETE MATERIALS AND REINFORCEMENT

- A. Concrete Materials and Reinforcement shall be in accordance with NCDOT standards, other applicable sections of these documents and Drawings.

2.3 BLOCK, STONE, AGGREGATE, AND SOIL MATERIALS

- A. Stone: In accordance with NCDOT, NCDEQ and these Drawings.
- B. Coarse Aggregate: In accordance with NCDOT standards.
- C. Soil Backfill: As specified in Division 31 of these specifications.

2.4 PIPE MATERIALS

- A. Pipe: At the type and size indicated on the drawings.

2.5 ACCESSORIES

- A. Anti-Seep Collar: Furnish according to NCDEQ standards.
- B. Trash Rack: Furnish according to NCDEQ standards.

2.6 SOURCE QUALITY CONTROL (AND TESTS)

- A. Section 014000 - Quality Requirements: Testing, inspection and analysis requirements.
- B. Perform tests on cement, aggregates, and mixes to ensure conformance with specified requirements.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Section 013000 - Administrative Requirements: Verification of existing conditions before starting Work.
- B. Verify compacted subgrade, granular base and stabilized soil is acceptable and ready to support devices and imposed loads.
- C. Verify gradients and elevations of base or foundation for other Work are correct.

3.2 DIVERSION CHANNELS

- A. Windrow excavated material on low side of channel.
- B. Compact to 95 percent maximum density.
- C. On entire channel area, apply soil supplements and sow seed as specified on the Drawings.
- D. Mulch seeded areas as specified on the Drawings.
- E. Install Work according to NCDEQ standards.

3.3 ROCK ENERGY DISSIPATOR

- A. Excavate to indicated depth of rock lining or nominal placement thickness indicated on Drawings. Remove loose, unsuitable material below bottom of rock lining, then replace with suitable material. Thoroughly compact and finish entire foundation area to firm, even surface.

- B. Lay and overlay geotextile fabric over substrate. Lay fabric parallel to flow from upstream to downstream. Overlap edges upstream over downstream and upslope over downslope. Provide a minimum overlap of six inches. Offset adjacent roll ends a minimum of 5 feet when lapped. Cover fabric as soon as possible and in no case leave fabric exposed more than 4 weeks.
- C. Carefully place rock on geotextile fabric to produce an even distribution of pieces, with minimum of voids and without tearing geotextile.
- D. Unless indicated otherwise, place full course thickness in one operation to prevent segregation and to avoid displacement of underlying material. Arrange individual rocks for uniform distribution.

3.4 ROCK APRON

- A. Construct generally in accordance with rock energy dissipator requirements to indicated shape and depth.

3.5 ROCK FILTER OUTLET

- A. Install Work according to NCDEQ standards.

3.6 SEDIMENTATION POND

- A. Clear and grub storage area and embankment foundation area site as specified in Section 311001.
- B. Excavate key trench for full length of dam.
- C. Install pipe spillway, with anti-seep collar attached, at location indicated.
- D. Place forms and reinforcing for concrete footing at bottom of riser pipe with trash rack and anti-vortex device. Construction of embankment and trench prior to placing pipe is not required.
- E. Mix, place, finish, and cure concrete, as specified in Section 033000.
- F. Do not use coarse aggregate as backfill material around pipe. Backfill pipe with suitable embankment material to prevent dam leakage along pipe.
- G. Construct rock apron at outlet end of pipe, as specified in this Section. Place embankment material, as specified in Section 312323. When required, obtain borrow excavation for formation of embankment, as specified in Section 312323.
- H. On entire sedimentation pond area, apply soil supplements and sow seed in accordance with NCDEQ requirements.
- I. Mulch seeded areas with hay as specified on the Drawings.

3.7 SEDIMENT TRAPS

- A. Clear site, as specified in Section 311000.

- B. Construct trap by excavating and forming embankments as specified in Section 312316, and Section 312323.
- C. Place coarse aggregate or rock at outlet as indicated on Drawings.
- D. Place geotextile fabric, as specified for rock energy dissipator.
- E. On entire sediment trap area, apply soil supplements and sow seed on the Drawings.
- F. Mulch seeded areas with hay as specified on Drawings.

3.8 SITE STABILIZATION

- A. Incorporate erosion control devices indicated on the Drawings into the Project at the earliest practicable time.
- B. Construct, stabilize and activate erosion controls before site disturbance within tributary areas of those controls.
- C. Stockpile and waste pile heights shall not exceed 35 feet. Slope stockpile sides at 2:1 or flatter.
- D. Stabilize any disturbed area of affected erosion control devices on which activity has ceased and which will remain exposed in accordance with the Drawings.
- E. Stabilize diversion channels, sediment traps, and stockpiles immediately.

3.9 FIELD QUALITY CONTROL

- A. Section 014000 - Quality Requirements 017000
- B. Execution and Closeout Requirements: Field inspecting, testing, adjusting, and balancing.
- C. Inspect erosion control devices on a weekly basis and after each runoff event. Make necessary repairs to ensure erosion and sediment controls are in good working order.

3.10 CLEANING

- A. Section 017000 - Execution and Closeout Requirements: Requirements for cleaning.
- B. When sediment accumulation in sedimentation structures has reached a point one-third depth of sediment structure or device, remove, and dispose of sediment.
- C. Do not damage structure or device during cleaning operations.
- D. Do not permit sediment to erode into construction or site areas or natural waterways.
- E. Clean channels when depth of sediment reaches approximately one-half channel depth.

3.11 PROTECTION

- A. Section 017000 - Execution and Closeout Requirements: Requirements for protecting finished Work.

END OF SECTION 312500

SECTION 31 3116 – TERMITE 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.

1.2 SUMMARY

- A. Section Includes:
 - 1. Soil treatment.
- B. Related Requirements:
 - 1. Section 06 1000 "Rough Carpentry" for wood preservative treatment by pressure process.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles for termite control products.
 - 2. Include the EPA-Registered Label for termiticide products.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: A specialist who is licensed according to regulations of authorities having jurisdiction to apply termite control treatment and products in jurisdiction where Project is located and who employs workers trained and approved by manufacturer to install manufacturer's products.

1.5 FIELD CONDITIONS

- A. Soil Treatment:
 - 1. Environmental Limitations: To ensure penetration, do not treat soil that is water saturated or frozen. Do not treat soil while precipitation is occurring. Comply with requirements of the EPA-Registered Label and requirements of authorities having jurisdiction.
 - 2. Related Work: Coordinate soil treatment application with excavating, filling, grading and concreting operations. Treat soil under footings, grade beams and ground-supported slabs before construction.

1.6 WARRANTY

- A. Soil Treatment Special Warranty: Manufacturer's standard form, signed by Applicator and Contractor, certifying that termite control work consisting of applied soil termiticide treatment will prevent infestation of subterranean termites. If subterranean termite activity or damage is discovered during warranty period, re-treat soil and repair or replace damage caused by termite infestation.
 - 1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS**2.1 MANUFACTURERS**

- A. Source Limitations: Obtain termite control products from single source from single manufacturer.

2.2 SOIL TREATMENT

- A. Termiticide: EPA-Registered termiticide acceptable to authorities having jurisdiction, in an aqueous solution formulated to prevent termite infestation.
 - 1. Service Life of Treatment: Soil treatment termiticide that is effective for not less than five years against infestation of subterranean termites.

PART 3 - EXECUTION**3.1 EXAMINATION**

- A. Examine substrates, areas, and conditions, with Applicator present, for compliance with requirements for moisture content of soil per termiticide label, interfaces with earthwork, slab and foundation work, landscaping, utility installation, and other conditions affecting performance of termite control.
- B. Proceed with application only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. General: Prepare work areas according to the requirements of authorities having jurisdiction and according to manufacturer's written instructions before beginning application and installation of termite control treatment(s). Remove extraneous sources of wood cellulose and other edible materials, such as wood debris, tree stumps and roots, stakes, formwork, and construction waste wood from soil within and around foundations.
- B. Soil Treatment Preparation: Remove foreign matter and impermeable soil materials that could decrease treatment effectiveness on areas to be treated. Loosen, rake, and level soil to be treated, except previously compacted areas under slabs and footings. Termiticides may be applied before placing compacted fill under slabs if recommended in writing by termiticide manufacturer.

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3.3 APPLYING SOIL TREATMENT

- A. Application: Mix soil treatment termiticide solution to a uniform consistency. Distribute treatment uniformly. Apply treatment at the product's EPA-Registered Label volume and rate for maximum specified concentration of termiticide to the following so that a continuous horizontal and vertical termiticidal barrier or treated zone is established around and under building construction.
 - 1. Slabs-on-Grade and Basement Slabs: Under ground-supported slab construction, including footings, building slabs, and attached slabs as an overall treatment. Treat soil materials before concrete footings and slabs are placed.
 - 2. Foundations: Soil adjacent to and along the entire inside perimeter of foundation walls; along both sides of interior partition walls; around plumbing pipes and electric conduit penetrating the slab; around interior column footers, piers, and chimney bases; and along the entire outside perimeter, from grade to bottom of footing.
 - 3. Masonry: Treat voids.
 - 4. Penetrations: At expansion joints, control joints, and areas where slabs and below-grade walls will be penetrated.
- B. Post warning signs in areas of application.
- C. Reapply soil treatment solution to areas disturbed by subsequent excavation, grading, landscaping, or other construction activities following application.

3.4 PROTECTION

- A. Avoid disturbance of treated soil after application. Keep off treated areas until completely dry.
- B. Protect termiticide solution dispersed in treated soils and fills from being diluted by exposure to water spillage or weather until ground-supported slabs are installed. Use waterproof barrier according to EPA-Registered Label instructions.

END OF SECTION 31 3116

SECTION 321123 - AGGREGATE BASE COURSES**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes:
 - 1. Aggregate subbase.
 - 2. Aggregate base course.

1.2 REFERENCES

- A. American Association of State Highway and Transportation Officials:
 - 1. AASHTO M288 - Standard Specification for Geotextile Specification for Highway Applications.
- B. ASTM International:
 - 1. ASTM D2940 - Standard Specification for Graded Aggregate Material for Bases or Subbases for Highways or Airports.
- C. North Carolina Department of Transportation (NCDOT):
 - 1. NCDOT Standard Specifications for Roads and Structures (NCDOT Specifications):
 - a. Section 520 - Aggregate Base Course.
 - b. Section 1010 - Aggregate for Non-Asphalt Type Bases.

1.3 SUBMITTALS

- A. Section 013300 - Submittal Procedures: Requirements for submittals.
- B. Product Data:
 - 1. Submit data for geotextile fabric and herbicide.
- C. Materials Source: Submit name of aggregate materials suppliers.
- D. Manufacturer's Certificate: Certify products meet or exceed specified requirements.
- E. Prior to Production:
 - 1. Identify aggregate source.
 - 2. Submit test results indicating aggregate meets material requirements of NCDOT Specifications.
 - 3. Submit job-mix gradation indicating single value for each sieve size required.
- F. Changes to Job-Mix Gradation: Submit in writing prior to start of day's production. Changes are subject to approval.
- G. Submit quality control test results within 24 hours after testing is completed.

1.4 QUALITY ASSURANCE

- A. Furnish each aggregate material from single source throughout the Work.
- B. Perform Work according to NCDOT of standards.

PART 2 - PRODUCTS

2.1 AGGREGATE MATERIALS

- A. Aggregate Base Course: Well-graded, clean, hard, tough, durable, and sound mineral aggregates consisting of crushed stone, crushed gravel, or crushed slag; free of organic matter and contamination from chemical or petroleum products; meeting the requirements of Division 10 within the NCDOT Standard Specifications for Roads and Structures.

2.2 ACCESSORIES

- A. Geotextile Fabric: AASHTO M288; non-woven, polypropylene.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Section 013000 - Administrative Requirements: Verification of existing conditions before starting Work.
- B. Verify compacted substrate is dry and ready to support paving and imposed loads.
 - 1. Proof roll substrate with 20-ton tandem axle dual wheel dump truck loaded to the legal limit with the tires inflated to 100 psi in minimum in two perpendicular passes to identify soft spots. Proof roll shall be done in the presence of the RPR and/or authorities having jurisdiction.
 - 2. Soft areas of the substrate that deflect more than 1 inch or show permanent deformations greater than 1 inch shall be removed and replaced with suitable materials or reworked to conform to the moisture content and compactions requirements in accordance with these specifications. Remove soft substrate and replace with compacted fill as specified in Section 312323.
- C. Verify substrate has been inspected, gradients and elevations are correct.

3.2 PREPARATION

- A. Correct irregularities in substrate gradient and elevation by scarifying, reshaping, and re-compacting.
- B. Do not place fill on soft, muddy, or frozen surfaces.
- C. Do not place aggregate base course until subgrade is accepted by ENGINEER or authorities having jurisdiction.

3.3 AGGREGATE PLACEMENT

- A. Install geotextile fabric over subgrade according to manufacturer's instructions.
 - 1. Lap ends and edges minimum 6 inches.
 - 2. Anchor fabric to subgrade when required to prevent displacement until aggregate is installed.
- B. Spread aggregate over prepared substrate and compact in accordance with NCDOT Specifications.
- C. Roller compact aggregate to 95 percent maximum density.
- D. Level and contour surfaces to elevations, profiles, and gradients indicated.
- E. Add small quantities of fine aggregate to coarse aggregate when required to assist compaction.
- F. Maintain optimum moisture content of fill materials to attain specified compaction density.
- G. Use mechanical tamping equipment in areas inaccessible to compaction equipment.

3.4 TOLERANCES

- A. Section 014000 - Quality Requirements: Tolerances.
- B. Maximum Variation From Flat Surface: 1/4 inch measured with 10 foot straight edge.
- C. Maximum Variation From Thickness: 1/4 inch.
- D. Maximum Variation From Elevation: 1/2 inch.

3.5 FIELD QUALITY CONTROL

- A. Section 014000 - Quality Requirements and 017000 - Execution and Closeout Requirements: Field inspecting, testing, adjusting, and balancing.
- B. Compaction testing will be performed according to NCDOT Specifications.
- C. When tests indicate Work does not meet specified requirements, remove Work, replace, and retest.
- D. Frequency of Tests: In accordance with NCDOT Specifications.

3.6 COMPACTION

- A. Compact materials to 98 percent of maximum density as determined from test strip, according to ASTM D2940.

END OF SECTION 321123

SECTION 321216 - ASPHALT PAVING**PART 1 - GENERAL****1.1 SUMMARY****A. Section Includes:**

1. Asphalt materials.
2. Aggregate materials.
3. Aggregate subbase.
4. Asphalt paving base course, binder course, and wearing course.
5. Asphalt paving overlay for existing paving.
6. Surface slurry.

1.2 REFERENCE STANDARDS**A. American Association of State Highway and Transportation Officials:**

1. AASHTO M288 - Standard Specification for Geotextile Specification for Highway Applications.
2. AASHTO M320 - Standard Specification for Performance-Graded Asphalt Binder.

B. North Carolina Department of Transportation (NCDOT):

1. NCDOT Standard Specifications for Roads and Structures (NCDOT Specifications):
 - a. Section 600 – Prime Coat.
 - b. Section 605 – Asphalt Tack Coat.
 - c. Section 607 – Milling Asphalt Pavement.
 - d. Section 609 – Quality Management System for Asphalt Pavements.
 - e. Section 610 – Asphalt Concrete Plant Mix Pavements.
 - f. Section 620 - Asphalt Binder for Plant Mix.
 - g. Section 657 - Sealing Existing Pavement Cracks and Joints.

C. NCDOT Asphalt Quality Management System, Materials and Tests Unit, Asphalt QMS Manual (QMS Manual), latest edition.**1.3 DEFINITIONS****A. Lot: Number of tons of asphalt pavement placed in production day.****B. Minor Target Change: Change from verified mix design gradation target on maximum of two sieves with limitations as follows:**

1. Maximum allowable change in target gradation on #8 or any coarser sieve is limited to 3 percent passing per sieve.
2. Maximum allowable change in target gradation on #16 or #50 sieves is 2 percent passing per sieve.
3. Maximum allowable change in target gradation on #200 sieve is 0.5 percent passing.
4. No target change may violate mix design requirements.

C. Non-Permeable Asphalt Pavement: Asphalt pavement that water will not penetrate through mix when water is placed on surface of pavement.

- D. Production Day: 24-hour period in which asphalt pavement is being placed.
- E. Screed: Any strike-off device operated by cutting, crowding or other practical action which is effective on mixture at workable temperature without tearing, shoving or gouging and which produces finished surface of evenness and texture specified.

1.4 COORDINATION

- A. Prepare weekly schedule detailing construction activities planned for following week. Present schedule to RPR before Friday, 12:00 pm (noon) of preceding effective date of schedule. Weekly meetings may be required to review construction activities as indicated by ENGINEER.

1.5 SUBMITTALS

- A. Section 013300 - Submittal Procedures: Requirements for submittals.
- B. Product Data:
 - 1. Submit product information for asphalt and aggregate materials.
 - 2. Submit mix design with laboratory test results supporting design.
- C. Manufacturer's Certificate: Certify Products meet or exceed specified requirements.
- D. Mix design: Submit at least 10 days before paving begins.
 - 1. Include test data used to develop mix design.
 - 2. Indicate single value for percentage of aggregate passing each sieve and asphalt cement content. Provide gradation within each band indicated.
- E. Changes to Mix Design: Submit in writing prior to production.
- F. Corrective action plan according to requirements of this Section.
- G. Weigh Tickets: Submit to ENGINEER at end of each workday. Keep duplicate copy of tickets.
- H. Sample: Provide sample to ENGINEER for calibration of burn off oven.

1.6 QUALITY ASSURANCE

- A. Mixing Plant: Conform to NCDOT standards.
- B. Obtain materials from same source throughout.
- C. Perform Work in accordance with NCDOT standards.

1.7 QUALIFICATIONS

- A. Installer: Company specializing in performing work of this section listed on NCDOT approved list.

1.8 AMBIENT CONDITIONS/LIMITATIONS

- A. Section 015000 - Temporary Facilities and Controls: Ambient conditions control facilities for product storage and installation.
- B. Do not place asphalt mixture between months specified in NCDOT Specifications/QMS Manual.
- C. Do not place asphalt mixture when ambient air or base surface temperature is less than 40 degrees F, or surface is wet or frozen.
- D. Do not place asphalt pavement when base has free surface water, base is oversaturated, or frozen.
- E. Do not place asphalt pavement during adverse weather conditions such as precipitation. If precipitation begins during paving operations, OWNER assumes no responsibility for asphalt left in trucks when paving operation is halted due to precipitation.
- F. Use release agent that does not dissolve asphalt and is acceptable to ENGINEER for equipment and hand tools used to mix, haul, and place asphalt pavement.
- G. Provide and have ready for use at all times enough tarpaulins or covers in case of precipitation or other delay, for covering or protecting any material dumped but not spread.

PART 2 - PRODUCTS**2.1 ASPHALT PAVING**

- A. Performance / Design Criteria:
- B. Asphalt Materials:
 - 1. Asphalt Surface/Binder/Intermediate Courses: AASHTO M320; performance grade PG 64-22 in accordance with NCDOT Specifications/QMS Manual.
 - a. Type: As listed on the Plan Drawings.
 - b. Depth: As listed on the Plan Drawings.
 - 2. Warm Mix: In accordance with NCDOT standards.
 - 3. Primer: In accordance with NCDOT standards.
 - 4. Tack Coat: In accordance with NCDOT standards.
 - 5. Reclaimed Asphalt Pavement (RAP): Processed material obtained by milling or full depth removal of existing asphalt paving.
 - 6. Oil: In accordance with of NCDOT standards.
- C. Aggregate Materials:
 - 1. Coarse Aggregate: In accordance with NCDOT standards.
 - 2. Fine Aggregate: In accordance with NCDOT standards.
 - 3. Mineral Filler: In accordance with NCDOT standards.
- D. Aggregate Subbase: Specified in Section 321123.

2.2 MIXES

- A. Use dry material to avoid foaming. Mix uniformly.

- B. Asphalt Paving Mixtures: Designed in accordance with NCDOT standards. Maximum percent by weight of reclaimed asphalt pavement in accordance with NCDOT standards.
 - 1. Base Course: Type and depth indicated on the Plan Drawings.
 - 2. Binder Course: Type and depth indicated on the Plan Drawings.
 - 3. Wearing Course: Type and depth indicated on the Plan Drawings, if applicable.

2.3 EQUIPMENT

- A. Asphalt Paver: Use self-propelled paver with screed capable of spreading mixture without segregation, placing to required grade, and confining mixture to true lines without use of stationary side forms. Paver must be equipped with acceptable automatic control system, which controls longitudinal grade and transfer slope, except when paving miscellaneous areas or when ENGINEER determines use of automatic control system is impractical. Use pick up conveyor or shuttle buggy to transfer asphalt mix from windrow to paver.
- B. Asphaltic Mixture Hauling Vehicles: Use trucks with tight clean and smooth boxes. End-Dump type vehicles are prohibited from dumping directly into paver.
- C. Rollers: Use rubber tire and steel self-propelled rollers in sufficient number to keep up with paver. Use release agent other than diesel. Use tandem rollers of 8- or 10-ton model weighing not less than 250 pounds per inch width of roller tread. Provide sufficient number and weight of rollers to compact mixture to required density while still in workable condition. Slurries used for surface repair contain fine aggregate. Type 1 is finest mix designed to penetrate surface cracks. Type 3 is coarsest used to build new wearing surface or to build crown. Use Type 2 to repair surface erosion and fill surface voids and build minimum wearing surface.

2.4 VOLUMETRIC DESIGN

- A. Perform Superpave Volumetric Mix Design according to NCDOT Standards and as follows:
 - 1. Determine optimum asphalt content by test data curves.
 - 2. Use test samples containing 0.5 percent increments of asphalt content.
 - 3. Include minimum of 2 test samples above and below optimum asphalt content.
- B. Mix Design Requirements:
 - 1. Hamburg Wheel Tracker: Maximum 10 mm impression at 20,000 passes.
 - 2. Number of Gyration:
 - a. N-initial = 7.
 - b. N-design = 75.
 - c. N-final = 115.
 - 3. Air Voids: 3 percent.
 - 4. Voids in Mineral Aggregate (VMA):
 - a. ¾ Inch Mix: 13.0% - 14%.
 - b. ½ Inch Mix: 14.0% - 15.0%.
 - c. 3/8 Inch Mix: 15.0% - 16.0%.
 - 5. Voids Filled with Asphalt (VFA): 70-80.
- C. If material source changes, develop new mix design prior to using new materials.
- D. Mix materials at central mixing plant. Use shortest mixing time needed to uniformly coat aggregate. Do not use material not mixed properly.
- E. Adjust production at mixing plant and delivery to maintain steady paving speed.

- F. Mix Design Changes:
 - 1. ENGINEER may allow up to two minor target changes per project without penalty to CONTRACTOR.

2.5 ACCESSORIES

- A. Geotextile Fabric: AASHTO M288; non-woven, polypropylene.
- B. Sealant: In accordance with NCDOT standards.

2.6 SOURCE QUALITY CONTROL

- A. Section 014000 - Quality Requirements: Testing, inspection and analysis requirements.
- B. Submit proposed mix design of each class of mix for review prior to beginning of Work.
- C. Test samples in accordance with in accordance with NCDOT standards.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Section 017000 - Execution and Closeout Requirements: Requirements for installation examination.
- B. Verify utilities indicated under paving are installed with excavations and trenches backfilled and compacted.
- C. Verify compacted subgrade, granular stabilized soil and/or subbase is dry and ready to support paving and imposed loads.
 - 1. Proof roll subbase with 20-ton tandem axle dual wheel dump truck loaded to the legal limit with the tires inflated to 100 psi in minimum in two perpendicular passes to identify soft spots. Proof roll shall be done in the presence of the RPR or authorities having jurisdiction.
 - 2. Soft areas of the substrate that deflect more than 1 inch or show permanent deformations greater than 1 inch shall be removed and replaced with suitable materials or reworked to conform to the moisture content and compactions requirements in accordance with these specifications. Remove soft substrate and replace with compacted fill as specified in Section 312323..
- D. Verify gradients and elevations of base are correct. Do not place asphalt concrete pavement until base course has been accepted by ENGINEER.
- E. Verify gutter drainage, grates and frames, manhole lids and frames and other utilities are installed in correct position and elevation.
- F. If Project is located near signalized intersection, contact NCDOT Division Traffic Engineer to schedule field location of traffic signal conflicts. Notify ENGINEER of any potential conflict prior to construction. Coordinate conflict relocation with NCDOT during construction.

3.2 PREPARATION

- A. Prepare subbase in accordance with NCDOT standards and these specifications.
- B. Do not start work until traffic control measures are in place.
- C. Locate and reference utility covers prior to paving operations.

3.3 DEMOLITION

- A. Where new pavement joins existing pavement, saw cut edge of existing pavement. Provide saw cut through full depth of pavement and in straight line. If pavement is cracked, broken or deteriorated, make saw cut so defective area is removed. Properly dispose of pavement removed by saw cutting. Remove dirt, sand, weeds, leaves, and other objectionable materials from prepared surfaces.
- B. Remove and dispose of existing portland cement concrete or asphalt pavement structure, including paved shoulders, within limits shown on Drawings or as indicated by ENGINEER. Remove and dispose of temporary roadway pavement structure placed for detours.
- C. Clean existing paving to remove foreign material, excess joint sealant and crack filler from paving surface.
- D. Where indicated, mill asphalt pavement in accordance with Section 607 of NCDOT Standards
- E. Where indicated, mill asphalt pavement in accordance with Section 607 of NCDOT Standards
- F. Repair surface defects in existing paving to provide uniform surface to receive new paving.

3.4 INSTALLATION

- A. Subbase:
 - 1. Prepare subbase in accordance with NCDOT standards and Section 321123.
- B. Primer:
 - 1. Apply primer in accordance with NCDOT standards.
 - 2. Use clean sand to blot excess primer.
- C. Tack Coat:
 - 1. Apply tack coat in accordance with NCDOT standards.
 - 2. Apply tack coat to contact surfaces of curbs, gutters and existing asphalt.
 - 3. Coat surfaces of manholes, catch basins and other utility frames with oil to prevent bond with asphalt paving. Do not tack coat these surfaces.
- D. Single Course Asphalt Paving:
 - 1. Install Work in accordance with NCDOT standards.
 - 2. Place asphalt within 24 hours of applying primer or tack coat.
 - 3. Place asphalt wearing course to thickness indicated on Drawings.

4. Compact paving by rolling to specified density. Do not displace or extrude paving from position. Hand compact in areas inaccessible to rolling equipment.
 5. Perform rolling with consecutive passes to achieve even and smooth finish without roller marks.
- E. Double Course Asphalt Paving:
1. Install Work in accordance with NCDOT standards.
 2. Place asphalt binder course within 24 hours of applying primer or tack coat.
 3. Place binder course to thickness indicated on Drawings.
 4. Place wearing course within 24 hours of placing and compacting binder course. When binder course is placed more than 24 hours before placing wearing course, clean surface and apply tack coat before placing wearing course.
 5. Place wearing course to thickness indicated on Drawings.
 6. Compact each course by rolling to specified density. Do not displace or extrude paving from position. Hand compact in areas inaccessible to rolling equipment.
 7. Perform rolling with consecutive passes to achieve even and smooth finish, without roller marks.
- F. Asphalt Paving Overlay
1. Apply tack coat to existing paving surface at rate recommended by geotextile fabric manufacturer.
 2. Install Work in accordance with NCDOT standards.
 3. Install geotextile fabric in accordance with manufacturer's instructions to permit asphalt saturation of fabric. Lap fabric edge and end joints 4 inches.
 4. Place wearing course to thickness indicated on Drawings.
- G. Compact overlay by rolling to specified density. Do not displace or extrude paving from position. Hand compact in areas inaccessible to rolling equipment.
- H. Perform rolling with consecutive passes to achieve even and smooth finish, without roller marks.
- I. Curbs:
1. Install extruded asphalt curbs of as indicated on Drawings.
- J. Joints:
1. Make in careful manner to provide well bonded and sealed joints.
 2. Apply tack coat as indicated. If necessary, heat joint.
 3. Offset longitudinal joints 6 to 12 inches in succeeding courses.
 4. Place top course joint within one foot of roadway centerline or lane line.
 5. Offset transverse construction joints at least 6 feet.
 6. For roller breakdown pass on confined edge, keep 6 inches from confined edge on hot side of mat to ensure joint density.
 7. For roller breakdown pass on unconfined edge, overlap unconfined edge at least 6 inches off of mat to prevent pavement from spreading.
 8. Compact joint density to at least 90 percent of rice density.
 9. Overlap screed onto previously placed mat $\frac{3}{4}$ to 1 inch maximum.
 10. Do not rake longitudinal joint.
- K. Compaction:
1. Start rolling as soon as mixture will bear roller without undue misplacement or hairline cracking. Delays in rolling hand raked mixture will not be tolerated.

2. Operate rollers with competent, experienced operator and kept in continuous operation as nearly as practicable.
 3. Start rolling longitudinally at outer edges and proceed toward center of pavement, overlapping on successive trips by at least one-half width of roller.
 4. Operate roller slow enough to avoid displacement mixture as a result of reversing. Correct any displacement immediately.
 5. Roll at rate not in excess of 500 square yards per hour per roller and continue until no further visible compaction is obtainable and roller marks have been eliminated.
 6. To prevent adhesion of mixture to roller, keep wheels moistened with water.
 7. In places not accessible to roller, compact thoroughly with hot tampers.
 8. Provide compaction and density control of asphalt in accordance with of Sections 609 and 610 of NCDOT Standards.
- L. Where exposed to traffic, taper end of course at approximately 50:1 (horizontal to vertical).
1. Remove portion of course that contains tapered end before placing fresh hot mix asphalt.
 2. Apply tack coat to contact surfaces of first course before fresh hot mix asphalt is placed against first course.
- M. Hand rake only when necessary.
- N. Set up exposed longitudinal edges of surface course by tamping with rake or lute at proper height and level to receive maximum compression under rolling.
- O. Place asphalt pavement to provide slope for drainage.
- P. Where indicated on Drawings, construct speed humps and/or raised crosswalks. Do not exceed maximum elevation indicated.
- Q. Utility Adjustments:
1. Adjust top of utility covers to match finish grade of asphalt pavement.
 2. Do not raise manhole or valve boxes for more than 14 days prior to resurfacing street.
 3. Immediately after making utility adjustment, paint sides of utility bright orange. Where necessary, place reflective orange traffic cones with 36-inch minimum height on utility.
 4. Notify OWNER if any broken manhole ring and cover, or valve boxes are discovered.

3.5 PAVEMENT REPAIR PATCH

- A. Where necessary to open cut along or across streets with asphalt surfaces, replace pavement with asphalt concrete intermediate course and asphalt concrete surface course to thickness indicated on Drawings.
- B. Extend replacement of base and asphalt pavement minimum of 1 foot on each side of excavated opening. Provide replacement material thickness sufficient to provide base and asphalt pavement of equivalent strength to undisturbed base and asphalt pavement.
- C. Meet applicable material and installation requirements.

3.6 CEASE PRODUCTION

- A. Cease production when any two out of three consecutive lots meet one of the following criteria:
1. Air voids at N-design averaged for each lot are less than 2.5 or greater than 4.75 percent.
 2. VMA at N-design averaged for each lot are not within plus or minus 1.25 percent of target value.

- B. Submit corrective action plan to ENGINEER before production continues indicating changes in production procedures that will be implemented to correct deficiencies. Address specific issues contributing to cease production directive. Submit for ENGINEER to review and accept revised plan before production continues.
- C. ENGINEER may require new mix design.
- D. ENGINEER may require Hamburg Wheel-Track testing for up to 5 lots after cease production order at no additional expense to OWNER.
 - 1. ENGINEER will take random sample at location behind paver for up to 5 lots after cease production order.
 - 2. Failure to meet mix design requirements will result in rejection of lot.

3.7 TOLERANCES

- A. Smoothness: Maximum variation of 1/4 inch measured longitudinally, transversely, and at construction joints with 10-foot straight edge or string line. Correct depressions or humps exceeding tolerances.
- B. Compacted Thickness:
 - 1. OWNER accepts lot for thickness when:
 - a. Average thickness of all sublots is not more than 1/2 inch greater, or 1/4 inch less than total thickness specified.
 - b. No individual subplot shows deficient thickness of more than 3/8 inch.
 - 2. Thickness:
 - a. Excess Thickness: ENGINEER may allow excess thickness to remain in place or may order excess thickness to be removed.
 - b. Deficient Thickness: Place additional material where lots or sublots are deficient in thickness.
- C. Variation from Indicated Elevation: Within 1/2 inch.
- D. Elevation Difference between Top of Asphalt Pavement and Gutter: Maximum 1.0 inch. Remove and replace asphalt pavement, or remedy as indicated by ENGINEER at no cost to OWNER.

3.8 FIELD QUALITY CONTROL

- A. Section 014000 - Quality Requirements: Requirements for inspecting, testing.
- B. Section 017000 - Execution and Closeout Requirements: Requirements for testing, adjusting, and balancing.
- C. Take samples and perform tests including asphalt paving thickness and mat density tests in accordance with NCDOT standards.
- D. Asphalt Paving Mix Temperature: Measure temperature at time of placement.

3.9 PROTECTION

- A. Section 017000 - Execution and Closeout Requirements: Requirements for protecting finished Work.

- B. Do not allow traffic to cross saw cut edge of existing pavement unless temporary ramp is constructed.
- C. Protect structures, and other objects from being spattered or marred by tack coat.
- D. Do not allow construction vehicles, general traffic, or rollers to pass over uncompacted end or edge of freshly placed mix until mat temperature drops to point where damage or differential compaction will not occur.
- E. Where necessary, protect pavement edges by placing planks of same thickness as pavement adjacent to longitudinal or transverse joints until surface course is completed.
- F. Immediately after placement, protect paving from mechanical injury for 3 hours or until surface temperature is less than 140 degrees F.

END OF SECTION 321216

SECTION 321313 - CONCRETE PAVING**PART 1 - GENERAL****1.1 SUMMARY****A. Section Includes:**

1. Aggregate subbase and base course.
2. Concrete paving for:
 - a. Concrete sidewalks.
 - b. Concrete stair steps.
 - c. Concrete integral curbs and gutters.
 - d. Concrete median barriers.
 - e. Concrete parking areas and roads.

1.2 REFERENCE STANDARDS**A. ASTM International:**

1. ASTM A767/A767M - Standard Specification for Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement.
2. ASTM A775/A775M - S Standard Specification for Epoxy-Coated Steel Reinforcing Bars.
3. ASTM A884/A884M - Standard Specification for Epoxy-Coated Steel Wire and Welded Wire Reinforcement.
4. ASTM C31/C31M - Standard Practice for Making and Curing Concrete Test Specimens in the Field.
5. ASTM C39/C39M - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
6. ASTM C94/C94M - Standard Specification for Ready-Mixed Concrete.
7. ASTM C143/C143M - Standard Test Method for Slump of Hydraulic Cement Concrete.
8. ASTM C172 - Standard Practice for Sampling Freshly Mixed Concrete.
9. ASTM C173/C173M - Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method.
10. ASTM C231 - Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.
11. ASTM C260 - Standard Specification for Air-Entraining Admixtures for Concrete.
12. ASTM C494/C494M - Standard Specification for Chemical Admixtures for Concrete.
13. ASTM C979 - Standard Specification for Pigments for Integrally Colored Concrete.
14. ASTM C1017/C1017M - Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete.
15. ASTM C1064/C1064M - Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete.
16. ASTM D1751 - Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types).

B. North Carolina Department of Transportation (NCDOT):

1. NCDOT Standard Specifications for Roads and Structures (NCDOT Specifications):

1.3 PRE-INSTALLATION MEETINGS

- A. Section 013000 - Administrative Requirements: Pre-installation meeting.
- B. Convene minimum one week prior to commencing work of this section.

1.4 SUBMITTALS

- A. Section 013300 - Submittal Procedures: Requirements for submittals.
- B. Product Data:
 - 1. Submit data on concrete materials, joint filler, admixtures, and curing compounds.
- C. Design Data:
 - 1. Submit concrete mix design for each concrete strength. Submit separate mix designs when admixtures are required for the following:
 - a. Hot and cold weather concrete work.
 - 2. Identify mix ingredients and proportions, including admixtures.
- D. Source Quality Control Submittals: Indicate results of tests and inspections.

1.5 QUALITY ASSURANCE

- A. Obtain cementitious materials from same source throughout.
- B. Perform Work according to NCDOT and Municipal of standards.

1.6 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing Products and listed on NCDOT's approved supplier list.
- B. Installer: Company specializing in performing work of this section and listed on NCDOT's approved installer list.

1.7 AMBIENT CONDITIONS

- A. Section 015000 - Temporary Facilities and Controls: Ambient conditions control facilities for product storage and installation.
- B. Do not place concrete when base surface temperature is less than 40 degrees F, or surface is wet or frozen.

PART 2 - PRODUCTS**2.1 AGGREGATE SUBBASE and BASE COURSE**

- A. Aggregate Subbase and Base Course: As specified in Section 321123.

2.2 CONCRETE PAVING

- A. Form Materials:

1. Form Materials: As specified in Section 031000.
2. Joint Filler: ASTM D1751; Asphalt impregnated fiberboard or felt, 1/4 inch thick.

- B. Reinforcement:

1. Reinforcing Steel and Wire Fabric: Type specified in Section 032000 or as indicated on the Plan Drawings.

- C. Concrete Materials:

1. Concrete Materials: As specified in Section 033000. Provide according to NCDOT of standards.
2. Water: ASTM C94/C94M; potable.
3. Air Entrainment: ASTM C260.
4. Chemical Admixture: ASTM C494/C494M. Use a quantity of chemical admixture within the range shown on the current list of approved admixtures issued by the Materials and Test Unit of NCDOT.
 - a. Type A - Water Reducing.
 - b. Type B - Retarding.
 - c. Type C - Accelerating.
 - d. Type D - Water Reducing and Retarding.
 - e. Type E - Water Reducing and Accelerating.
 - f. Type F - Water Reducing, High Range.
 - g. Type G - Water Reducing, High Range and Retarding.
5. Fly Ash: In accordance with NCDOT standards.
6. Slag: In accordance with NCDOT standards.
7. Plasticizing: ASTM C1017/C1017M Type I, plasticizing or Type II, plasticizing and retarding.
8. Color Pigment: ASTM C979; mineral oxides, alkali and fade resistant.
 - a. Color: As directed by the ENGINEER and OWNER.

2.3 FABRICATION

- A. Fabricate reinforcing according to NCDOT standards.
- B. Form standard hooks for 180-degree bends, 90-degree bend, and seismic hooks as indicated on Drawings.

2.4 MIXES

- A. Concrete Mix:
 - 1. Select proportions for normal weight concrete according to NCDOT standards.
 - 2. Provide concrete compressive strength, slump, minimum cement content and air entrainment in accordance with NCDOT Standard Specifications for Roads and Structures, latest edition, Section 1000.
 - 3. Limit the following cementitious materials to maximum percentage by mass of all cementitious materials:
 - a. Fly Ash: In accordance with NCDOT standards.
 - b. Blast Furnace Slag: In accordance with NCDOT standards.
 - c. Fly Ash and Blast Furnace Slag: In accordance with NCDOT standards.
 - 4. Use accelerating admixtures in cold weather only when approved by the ENGINEER in writing. Use of admixtures will not relax cold weather placement requirements.
 - 5. Use calcium chloride only when approved by the ENGINEER in writing.
 - 6. Use set retarding admixtures during hot weather only when approved by the ENGINEER in writing.

2.5 FINISHES

- A. Shop Finishing - Reinforcement:
 - 1. Galvanized Finish for Steel Bars: ASTM A767/A767M, Class I, hot dip galvanized after fabrication.
 - 2. Epoxy Coated Finish for Steel Bars: ASTM A775/A775M.
- B. Epoxy Coated Finish for Steel Wire: ASTM A884/A884M; Class A, using ASTM A775/A775M.

2.6 ACCESSORIES

- A. Curing Compounds: In accordance with NCDOT standards.
- B. Liquid Surface Sealer: In accordance with NCDOT standards.
- C. Surface Retarder: In accordance with NCDOT standards.
- D. Joint Sealers: Specified in Section 079000.

2.7 SOURCE QUALITY CONTROL

- A. Section 014000 - Quality Requirements: Testing and Inspection Services:
- B. Submit proposed mix design of each class of concrete to ENGINEER for review prior to commencement of Work.
- C. Tests on cement, aggregates, and mixes shall be performed to ensure conformance with specified requirements.
- D. Test samples according to ASTM C94/C94M

PART 3 - EXECUTION**3.1 EXAMINATION**

- A. Section 017000 - Execution and Closeout Requirements: Requirements for installation examination.
- B. Verify compacted subbase, subgrade, granular fill, or stabilized soil is dry and ready to support paving and imposed loads.
 - 1. Proof roll subbase, subgrade, granular fill, or stabilized soil with 20-ton tandem axle dual wheel dump truck loaded to the legal limit with the tires inflated to 100 psi in minimum in two perpendicular passes to identify soft spots. Proof roll shall be done in the presence of the RPR or authorities having jurisdiction.
 - 2. Soft areas of the subbase, subgrade, granular fill, or stabilized soil that deflect more than 1 inch or show permanent deformations greater than 1 inch shall be removed and replaced with suitable materials or reworked to conform to the moisture content and compactions requirements in accordance with these specifications. Remove soft subbase, subgrade, granular fill, or stabilized soil and replace with compacted fill as specified in Section 312323.
 - 3.
- C. Verify gradients and elevations of base are correct.

3.2 PREPARATION

- A. Section 017000 - Execution and Closeout Requirements: Requirements for installation preparation.
- B. Moisten substrate to minimize absorption of water from fresh concrete.
- C. Coat surfaces of utility structure frames with oil to prevent bond with concrete paving.
- D. Notify ENGINEER minimum 24 hours prior to commencement of concreting operations.

3.3 INSTALLATION

- A. Subbase and Base Course:
 - 1. Aggregate Subbase and Base Course: Install as specified in Section 321123.
- B. Forms:
 - 1. Place and secure forms and screeds to correct location, dimension, profile, and gradient.
 - 2. Assemble formwork to permit easy stripping and dismantling without damaging concrete.
- C. Reinforcement:
 - 1. Place reinforcing as indicated on Drawings.
 - 2. Interrupt reinforcing at contraction and expansion joints.
 - 3. Place dowels and reinforcing to achieve paving and curb alignment as detailed.
 - 4. Provide doweled joints as indicated on the Drawings.
 - 5. Repair damaged galvanizing to match shop finish.

D. Placing Concrete:

1. Coordinate installation of snow melting components.
2. Place concrete as specified in Section 033000.
3. Ensure reinforcing, inserts, embedded parts, and formed joints are not disturbed during concrete placement.
4. Place concrete continuously over the full width of the panel and between predetermined construction joints.
5. Place concrete to pattern indicated.

E. Joints

1. Saw cut contraction joints 3/16 inch wide at an optimum time after finishing. Cut 1/3 into depth of slab.
2. Seal joints as indicated on Drawings according to Section 079000.

F. Exposed Aggregate:

1. Apply surface retarder where exposed aggregate finish is required.
2. Wash exposed aggregate surface with clean water and scrub with stiff bristle brush exposing aggregate to match plan requirements.

G. Finishing:

1. Area Paving: Wood float.
2. Sidewalk Paving: Light broom radius, and trowel joint edges.
3. Median Barrier: Light broom radius, and trowel joint edges.
4. Curbs and Gutters: Light broom.
5. Direction of Texturing: Transverse to paving direction.
6. Inclined Vehicular Ramps: Broomed perpendicular to slope.
7. Place curing compound on exposed concrete surfaces immediately after finishing.

H. Curing and Protection

1. Immediately after placement, protect concrete from premature drying, excessively hot or cold temperatures, and mechanical injury.
2. Maintain concrete with minimal moisture loss at relatively constant temperature for period necessary for hydration of cement and hardening of concrete.
3. Cure concrete floor surfaces as specified in Section 033900.

3.4 TOLERANCES

- A. Section 014000 - Quality Requirements: Tolerances.
- B. Maximum Variation of Surface Flatness: 1/4 inch
- C. Maximum Variation From True Position: 1/4 inch.

3.5 FIELD QUALITY CONTROL

- A. Section 014000 - Quality Requirements: Requirements for inspecting and testing.
- B. Section 017000 - Execution and Closeout Requirements: Requirements for testing, adjusting, and balancing.

- C. Perform field inspection and testing according to ASTM C94/C94M and NCDOT of standards.
- D. Inspect reinforcing placement for size, spacing, location, support.
- E. Testing firm shall take cylinders and perform slump and air entrainment tests according to NCDOT standards.
- F. Strength Test Samples:
 - 1. Sampling Procedures: ASTM C172.
 - 2. Cylinder Molding and Curing Procedures: ASTM C31/C31M, cylinder specimens, standard cured.
 - 3. Sample concrete and make one set of five cylinders for every 75 cu yds or less of each class of concrete placed each day and for every 5,000 sf of surface area paving.
- G. Field Testing:
 - 1. Slump Test Method: ASTM C143/C143M.
 - 2. Air Content Test Method: ASTM C173/C173M.
 - 3. Temperature Test Method: ASTM C1064/C1064M.
 - 4. Measure slump and temperature for each compressive strength concrete sample.
 - 5. Measure air content in air entrained concrete for each compressive strength concrete sample.
- H. Cylinder Compressive Strength Testing:
 - 1. Test Method: ASTM C39/C39M.
 - 2. Test Acceptance: according to NCDOT standards.
 - 3. Test cylinders in accordance with NCDOT standards.
 - 4. Retain one cylinder for 56 days for testing when requested by ENGINEER.
 - 5. Dispose remaining cylinders when testing is not required.
- I. Maintain records of placed concrete items. Record date, location of pour, quantity, air temperature, and test samples taken.

3.6 PROTECTION

- A. Section 017000 - Execution and Closeout Requirements: Requirements for protecting finished Work.
- B. Immediately after placement, protect paving from premature drying, excessive hot or cold temperatures, and mechanical injury.
- C. Do not permit pedestrian or vehicular traffic over paving until accepted by ENGINEER.

END OF SECTION 321313

SECTION 321723 - PAVEMENT MARKINGS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Traffic lines and markings.
 - 2. Legends.
 - 3. Paint.
 - 4. Glass beads.

1.2 REFERENCE STANDARDS

- A. American Association of State Highway and Transportation Officials:
 - 1. AASHTO M247 - Standard Specification for Glass Beads Used in Pavement Markings.
- B. Manual on Uniform Traffic Control Devices (MUTCD)

1.3 SUBMITTALS

- A. Section 013300 - Submittal Procedures: Requirements for submittals.
- B. Product Data: Submit paint formulation for each type of paint.
- C. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.
- D. Test and Evaluation Reports: Indicate source and acceptance test results according to AASHTO M247.
- E. Manufacturer Instructions:
 - 1. Submit instructions for application temperatures, eradication requirements, application rate, line thickness, type of glass beads, and bead embedment and application rate.
 - 2. Submit detailed instructions on installation requirements, including storage and handling procedures.
- F. Source Quality-Control Submittals: Indicate results of factory tests and inspections.
- G. Field Quality-Control Submittals: Indicate results of CONTRACTOR-furnished tests and inspections.
- H. Qualifications Statements:
 - 1. Submit qualifications for manufacturer and applicator.
 - 2. Submit manufacturer's approval of applicator.

1.4 QUALITY ASSURANCE

- A. Perform Work according to MUTCD and/or municipal standards, as applicable.

1.5 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing products specified in this Section with minimum three years' documented experience.
- B. Applicator: Company specializing in performing Work of this Section with minimum three years' documented experience and approved by manufacturer.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Section 016000 - Product Requirements: Requirements for transporting, handling, storing, and protecting products.
- B. Inspection: Accept materials on Site in manufacturer's original packaging and inspect for damage.
- C. Storage:
 - 1. According to manufacturer instructions.
 - 2. Paint:
 - a. Invert containers several days prior to use if paint has been stored more than two months.
 - b. Minimize exposure to air when transferring paint.
 - c. Seal drums and tanks when not in use.
- D. Protection:
 - 1. Protect materials from moisture and dust by storing in clean, dry location remote from construction operations areas.
 - 2. Provide additional protection according to manufacturer instructions.

1.7 AMBIENT CONDITIONS

- A. Section 015000 - Temporary Facilities and Controls: Requirements for ambient condition control facilities for product storage and installation.
- B. Do not apply materials if surface and ambient temperatures are outside temperature ranges required by paint product manufacturer.
- C. Do not apply exterior coatings during rain or snow if relative humidity is outside range required by paint manufacturer, or if moisture content of surfaces exceeds that required by paint manufacturer.
- D. Minimum Conditions: Do not apply paint if temperatures are expected to fall below 60 deg. F within 24 hours after application or in accordance with manufacturer recommendations.

- E. Thermoplastic Compound: Do not apply unless pavement surface temperature is minimum 40 deg. F and rising.
- F. Maximum VOCs: Do not exceed limit required by State or Environmental Protection Agency.

1.8 WARRANTY

- A. Section 017000 - Execution and Closeout Requirements: Requirements for warranties.
- B. Furnish two-year manufacturer's warranty for pavement markings.

PART 2 - PRODUCTS

2.1 PAINTED PAVEMENT MARKINGS

A. Manufacturers:

- 1. Aexcel Inc.
- 2. Color Wheel Paints & Coatings.
- 3. Columbia Paint & Coatings, Inc.; a subsidiary of Sherwin-Williams Company (The).
- 4. Conco Paints.
- 5. Coronado Paint; Benjamin Moore & Co.
- 6. Diamond Vogel Paints.
- 7. Ennis-Flint.
- 8. EZ-Liner Industries.
- 9. Franklin Paint Company.
- 10. McCormick Paints.
- 11. Pathmark Traffic Products of Texas Inc.
- 12. Safety Coatings, Inc.
- 13. Scott Paint.
- 14. Substitutions: As specified in Section 016000 - Product Requirements.

B. Performance and Design Criteria:

- 1. Paint Adhesion: Adhere to road surface, forming smooth continuous film one minute after application.
- 2. Paint Drying: Tack free by touch as not to transfer by vehicle tires within two minutes after application.

C. Paint:

- 1. Description: Ready mixed, conventional, fast-dry, waterborne traffic paints.
- 2. Lead-free and nontoxic.
- 3. Minimum Retroreflectance: In accordance with MUTCD standards.
- 4. Durability Rating: 6 or more, after in place for nine months.
- 5. Properties:
 - a. Pigment Percent by Weight: In accordance with MUTCD standards.
 - b. Vehicle Percent by Weight: In accordance with MUTCD standards.
 - c. Nonvolatile Percent by Weight of Paint: In accordance with MUTCD standards.
 - d. Minimum Density: In accordance with MUTCD standards.
 - e. Viscosity: In accordance with MUTCD standards.

6. Grind:
 - a. Method: Hegeman Gage.
 - b. Minimum Field-Tested, No-Tracking Time under Ambient Conditions: 20 to 90 seconds.
7. Maximum Dry-Through Time: In accordance with manufacturer standards.
8. Maximum VOC Content: In accordance with state standards.

D. Glass Beads:

1. Comply with AASHTO M247, Type 1.
2. Coating: Enhance embedment and adherence with paint.

E. Thermoplastic Compound:

1. Binder Component: Hydrocarbon resin with pigment, beads, and filler uniformly dispersed.
2. Asphalt Concrete Primer:
 - a. Description: Thermosetting adhesive with a solids content of pigment reinforced synthetic rubber and synthetic plastic resin dissolved or dispersed in a volatile organic solvent.
 - b. Solids Content: Not less than 10 percent by weight at 70 deg. F and 60 percent relative humidity.
 - c. Wet Film Thickness: 0.005 inch, plus or minus 0.03 inch.
3. Portland Cement Concrete Primer: Epoxy resin primer, as recommended by manufacturer of thermoplastic compound.

F. Preformed Tape:

1. Description: Adherent reflectorized strip.
2. Comply with state standards.

G. Raised Pavement Markers:

1. Type/Standards: In accordance with state standards.

2.2 APPLICATION EQUIPMENT

A. Paint Gun:

1. Description: Simultaneously apply parallel lines of indicated width in solid or broken patterns or various combinations of those patterns.
2. Type: Dual nozzle.

B. Bead Gun:

1. Description: Automatically dispense glass beads onto painted surface at required application rate.
2. Type: Pressurized.

- C. Measuring Device: Automatically and continuously measure to nearest foot length of each line placed.
- D. Paint Heater: Capable of heating paint as indicated by manufacturer recommendations for fast-dry applications.

2.3 SOURCE QUALITY CONTROL

- A. Section 014000 - Quality Requirements: Requirements for testing, inspection, and analysis.
- B. Test and analyze traffic paints according state standards.
- C. OWNER Inspection:
 - 1. Make completed paints and glass beads available for inspection at manufacturer's factory prior to packaging for shipment.
 - 2. Notify OWNER at least seven days before inspection is allowed.
- D. OWNER Witnessing:
 - 1. Allow witnessing of factory inspections and tests at manufacturer's test facility.
 - 2. Notify OWNER at least seven days before inspections and tests are scheduled.
- E. Certificate of Compliance:
 - 1. If manufacturer is approved by authorities having jurisdiction, submit certificate of compliance indicating Work performed at manufacturer's facility conforms to Contract Documents.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Section 017000 - Execution and Closeout Requirements: Requirements for application preparation.
- B. Do not apply paint to concrete surfaces until concrete has cured for 28 days.
- C. Agitate paint for 1 to 15 minutes prior to application to ensure even distribution of pigment.
- D. Maintenance and Protection of Traffic:
 - 1. Provide short-term traffic control as specified in Section 015000 - Temporary Facilities and Controls.
 - 2. Prevent interference with marking operations and prevent traffic on newly applied markings before dry.
 - 3. Maintain travel lanes in specified times in accordance with authorities having jurisdiction.
 - 4. Maintain access to existing businesses,, and other properties requiring access.
- E. Surface Preparation.
 - 1. Clean and dry paved surfaces prior to painting.

2. Blow or sweep surface free of dirt, debris, oil, grease, or gasoline.
3. Spot location of final pavement markings, as specified and as indicated on Drawings, by applying pavement spots 25 feet on center.
4. Request inspection by ENGINEER after placing pavement spots and minimum three days prior to applying traffic lines.

3.2 DEMOLITION

- A. Remove existing markings in an acceptable manner, using methods that will cause least damage to pavement structure or surface. Removal shall be in accordance with state standards.
- B. Do not remove existing pavement markings by painting over with blank paint.
- C. Repair pavement or surface damage caused by removal methods.
- D. Clean and repair existing, remaining, or reinstalled lines and legends.

3.3 APPLICATION

A. Application Rate:

1. Reflective Markings:

- a. Paint: In accordance with state standards.
- b. Glass Spheres on Wet Paint: In accordance with state standards.

2. Nonreflective Markings:

- a. Paint: In accordance with state standards.

3. Thermoplastic Compound:

- a. After surface preparation has been completed, prime pavement surface with spray equipment and allow primer materials to dry according to thermoplastic manufacturer recommendations.
- b. Apply thermoplastic at temperatures not less than recommended by manufacturer.
- c. Apply reflective glass spheres mechanically at rates recommended by manufacturer.
- d. Application Thickness: In accordance with state standards.

B. Painting:

1. Apply paint pneumatically, using guidelines and templates as necessary to control application.
2. Manually paint numbers, letters, and symbols.
3. Prevent splattering and overspray when applying markings.
4. Paint Guns: Simultaneously apply paint binder at uniform specified rates.
5. Dispense at ambient temperature.
6. Wet-Film Thickness:
 - a. 15 mils.
 - b. Edge Markings: 12 mils.

C. Reflective Media:

1. Immediately follow paint application.
2. Bead Guns:
 - a. Dispense glass beads simultaneously at specified rate.
 - b. Check guns by dispensing glass beads into gallon container for predetermined fixed period of time.
 - c. Verify weight of glass beads.

D. Thermoplastic Compound:

1. Place on dry pavement.
2. Apply centerline, skip line, edge line, and other longitudinal type markings with mobile applicator.
3. Place special markings, crosswalks, stop bars, legends, arrows, and similar patterns with portable applicator.

E. Raised Pavement Markers:

1. Align prefabricated markers and permanently fix in place by means of epoxy adhesives.
2. Prior to applying adhesive, thoroughly clean area by water blasting and by compressed air.

F. Dimensions and Locations: As indicated on Drawings.

G. Installation Standards: Install Work according to MUTCD/state standards.

3.4 TOLERANCES

- A. Section 014000 - Quality Requirements: Requirements for tolerances.
- B. Maximum Variation from Wet Film Thickness: In accordance with state standards.
- C. Maximum Variation from Wet Paint Line Width: In accordance with state standards.
- D. Automatic Line-Length Gages: In accordance with state standards.
- E. Cycle Length Timer: In accordance with state standards.
- F. Paint Line-Length Timer: In accordance with state standards.
- G. Paint Guns: In accordance with state standards.

3.5 FIELD QUALITY CONTROL

- A. Section 014000 - Quality Requirements: Requirements for inspecting and testing.
- B. Section 017000 - Execution and Closeout Requirements: Requirements for testing, adjusting, and balancing.
- C. Inspect for incorrect location, insufficient thickness, line width, coverage, retention, uncured or discolored material, and insufficient bonding.

D. Acceptance:

1. Repair lines and markings which after application and curing do not meet following criteria:
 - a. Incorrect location.
 - b. Insufficient thickness, width, coverage, or retention.
 - c. Uncured or discolored material.
 - d. Insufficient bonding.

3.6 CLEANING

- A. Section 017000 - Execution and Closeout Requirements: Requirements for cleaning.
- B. Collect and legally dispose of residues from painting operations.

3.7 PROTECTION

- A. Section 017000 - Execution and Closeout Requirements: Requirements for protecting finished Work.
- B. Protect painted pavement markings from vehicular and pedestrian traffic until paint is dry and track free.
- C. Unless material is track free at end of paint application convoy, use traffic cones to protect markings from traffic until track free.
- D. If vehicle crosses a marking and tracks it, or if splattering or overspray occurs, eradicate affected marking and resultant tracking and apply new markings.
- E. Follow manufacturer instructions or use minimum of 30 minutes of dry time.
- F. Barrier cones are satisfactory protection for materials being dried.

3.8 MAINTENANCE

- A. Section 017000 - Execution and Closeout Requirements: Requirements for maintenance service.
- B. Provide service and maintenance of traffic paints for two years from date of Substantial Completion.

END OF SECTION 321723

SECTION 329200 - TURF AND GRASSES**PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Seeding
 - 2. Sodding
 - 3. Turf renovation
- B. Related Sections include the following:
 - 1. Division 01 General Requirements
 - 2. Division 31 Earthwork.
 - 3. Division 32 Exterior Improvements.

1.3 DEFINITIONS

- A. Finish Grade: Elevation of finished surface of planting soil.
- B. Manufactured Soil: Soil produced off-site by homogeneously blending mineral soils or sand with stabilized organic soil amendments to produce topsoil or planting soil.
- C. Planting Soil: Standardized topsoil; existing, native surface topsoil; existing, in-place surface soil; imported topsoil; or manufactured topsoil that is modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.
- D. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or top surface of a fill or backfill immediately beneath planting soil.
- E. Subsoil: All soil beneath the topsoil layer of the soil profile, and typified by the lack of organic matter and soil organisms.
- F. Surface Soil: Soil that is present at the top layer of the existing soil profile at the Project site. In undisturbed areas, the surface soil is typically topsoil, but in disturbed areas such as urban environments, the surface soil can be subsoil.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated, including planting soil.
 - 1. Pesticides and Herbicides: Include product label and manufacturer's application instructions specific to this Project.
- B. Certification of Grass Seed: From seed vendor for each grass-seed monostand or mixture stating the botanical and common name and percentage by weight of each species and variety, and percentage of purity, germination, inert matter, noxious weeds by name & % per pound and weed seed. Include the year of production and date of packaging.

- C. Product Certificates: For soil amendments and fertilizers, signed by product manufacturer.
- D. Qualification Data: For landscape Installer. Include key personnel background and list of similar projects, minimum 3 projects completed and 5 years of experience in turf installation by Installer demonstrating Installer's capabilities and experience. Include project names, addresses, and year completed, and include names and addresses of owners' contact persons.
- E. Material Test Reports: For existing surface soil and imported or manufactured topsoil.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: A qualified landscape installer shall be a licensed Landscape Contractor. Only a landscape Contractor as defined by the General Statutes of North Carolina and licensed in North Carolina shall be permitted to perform this work. A copy of the Landscape Contractor's License or License Number shall be presented to the Owner's representative at the time the contract is executed
 - 1. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when planting is in progress.
 - 2. Personnel Certifications: Installer's field supervisor shall have certification with the Turfgrass Council of North Carolina
 - 3. Pesticide Applicator: State licensed, commercial.

Soil-Testing Laboratory Qualifications: An independent laboratory, recognized by the State Department of Agriculture, with the experience and capability to conduct the testing indicated and that specializes in types of tests to be performed.

- B. Soil Analysis: Furnish soil analysis by a qualified soil-testing laboratory stating percentages of organic matter; gradation of sand, silt, and clay content; cation exchange capacity; deleterious material; pH; and mineral and plant-nutrient content of the soil.
 - 1. Based on the test results, state recommended quantities of nitrogen, phosphorus, and potash nutrients and soil amendments to be added to produce satisfactory planting soil.
 - 2. Report presence of problem salts, minerals, or heavy metals, including aluminum, arsenic, barium, cadmium, chromium, cobalt, lead, lithium, and vanadium. If such problem materials are present, provide additional recommendations for corrective action.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Seed: Deliver seed in original sealed, labeled, and undamaged containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws, as applicable.
- B. Sod: Harvest, deliver, store, and handle sod according to requirements in Turfgrass Producers International's "Specifications for Turfgrass Sod Materials" and "Specifications for Turfgrass Sod Transplanting and Installation" in its "Guideline Specifications to Turfgrass Sodding." or other approved professional organization such as North Carolina State University's Turf Files or Clemson University. Deliver sod in time for planting within 24 hours of harvesting. Protect sod from breakage and drying.
- C. Bulk Materials:
 - 1. Do not dump or store bulk materials near structures, utilities, walkways and

- pavements, or on existing turf areas or plants.
- 2. Provide erosion control measures to prevent erosion or displacement of bulk materials, discharged of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
- 3. Accompany each delivery of bulk fertilizers, lime, and soil amendments with appropriate certificates.

1.7 COORDINATION

- A. Planting Restrictions: Plant during one of the following periods. Coordinate planting periods with maintenance periods to provide required maintenance from date of Substantial Completion. Variation in schedule shall be pre-approved by Owner.

1. Temporary Seeding Schedule:

Date	Type	Min.Application Rate
Sept. 15 – Mar. 30	Tall Fescue and	250 lbs/acre
	Winter Rye	50 lbs/acre
Apr. 1 – Sept. 15	Tall Fescue and	250 lbs/acre
	German Millet or	25 lbs/acre
	Sudangrass (small-stemmed var.)	30 lbs/acre

2. Permanent Seeding Schedule – Turf Areas

Date	Type	Min.Application Rate
Apr. 1 – July 15	Common Bermudagrass or	75 lbs/acre
	Improved Bermudagrass	
Sept. 1 – Oct 15	Turf Type Tall Fescue	350 lbs/acre

3. Permanent Sodding Schedule – Turf

Areas	Date	Type
May 15 – Sept. 15		Bermudagrass
Sept 15 – Dec. 1		Turf Type Tall Fescue

- B. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit.
- C. Planting outside of the specified window only as approved by Landscape Architect. Extension of maintenance and warranty periods and additional required watering for planting outside of defined windows may apply at discretion of Landscape Architect

1.8 MAINTENANCE SERVICE

- A. Provide complete maintenance by skilled employees of landscape installer. Maintain as required in Part 3. Begin maintenance immediately after each area is planted and continue until acceptable turf or naturalized grass, including meadow and no-mow grasses, is established, for not less than 90 days from Substantial Completion, or as directed by Owner.
- B. Maintenance Service: Submit to Owner on first day of month Maintenance Report Form (provided) showing weekly maintenance completed. Owner shall verify and sign off on Maintenance Report Form prior to maintenance payment.

1.9 SATISFACTORY TURF AND GRASSES

- A. Turf maintenance: Installer shall repair or replace turf and accessories that fail in materials, workmanship, or growth within **90 days** from Substantial Completion. Turf shall meet the following criteria as determined by Architect:

1. Satisfactory Seeded Turf: At end of maintenance period, a healthy, uniform, close stand of grass has been established, free of weeds and surface irregularities, with coverage exceeding 90 percent over any 10 sq. ft. and bare spots not exceeding 6 by 6 inches.
 2. Satisfactory Sodded Turf: At end of maintenance period, a healthy, well-rooted, even-colored, viable turf has been established, free of weeds, open joints, bare areas, and surface irregularities.
- B. Renovate, reseed or replace unsatisfactory turf, as required in Part 3, at end of **specified maintenance period**.

PART 2 - PRODUCTS

2.1 SEED

- A. Grass Seed: Fresh, clean, dry, new-crop seed complying with AOSA's "Journal of Seed Technology; Rules for Testing Seeds" for purity and germination tolerances.
- B. Seed Species: Seed of grass species as follows, with not less than 95 percent germination, not less than 85 percent pure seed, and not more than 0.5 percent weed:
1. Permanent seeding: Common Bermudagrass (Hulled)
Turf Type Tall Fescue Improved Bermudagrass
 2. Temporary seeding: Tall Fescue and Winter Rye
Tall Fescue and, German Millet or Sudangrass

2.2 TURFGRASS SOD

- A. Turfgrass Sod: Certified complying with TPI's "Specifications for Turfgrass Sod Materials" in its "Guideline Specifications to Turfgrass Sodding." Furnish viable sod of uniform density, color, and texture, strongly rooted, and capable of vigorous growth and development when planted.
- B. Turfgrass Species: Sod of grass species as follows, with not less than 95 percent germination, not less than 85 percent pure seed, and not more than 0.5 percent weed seed
1. Tifway 419, TifTuf, or Turf Type Tall Fescue, or as approved by Landscape Architect

2.3 PLANTING SOILS

- A. Topsoil: ASTM D 5268, pH range of 6.0 to 7.0, a minimum of 6 percent organic material content; free of stones 1/2" or larger in any dimension and other extraneous materials harmful to plant growth.
1. Topsoil Source: Reuse surface soil stockpiled on-site. Verify suitability of stockpiled surface soil to produce topsoil. Clean surface soil of roots, plants, sod, stones, clay lumps, and other extraneous materials harmful to plant growth.
 2. Supplement with imported or manufactured topsoil from off-site sources when quantities are insufficient. Obtain topsoil displaced from naturally well-drained construction or mining sites where topsoil occurs at least 4 inches (100 mm) deep; do not obtain from agricultural land, bogs or marshes.
- B. Topsoil stripped and stockpiled from the site shall be used in plant beds, tree pits and turf areas
- C. Have topsoil tested by a certified soil testing laboratory to determine the type and quantity

of soil amendments necessary. Add amendments to topsoil as necessary to meet these requirements.

2.4 PLANTING ACCESSORIES

- A. Selective Herbicides: EPA registered and approved, of type recommended by manufacturer for application.

2.5 FERTILIZER

- A. Bonemeal: Commercial, raw or steamed, finely ground; a minimum of 4 percent nitrogen and 20 percent phosphoric acid.
- B. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following composition:
 - 1. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing agency.
- C. Slow-Release Fertilizer: Granular or pelletized fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:
 - 1. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing agency.
 - 2. Fish-emulsion, compost tea.
- D. Other Organic Fertilizer: Contractor is encouraged to utilize other organic fertilizer with a lower nitrogen value, such as worm castings, sewage sludge. Contractor shall submit product information for Architect's approval prior to application.

2.6 MULCHES

- A. Straw Mulch: Provide air-dry, clean, mildew- and seed-free, salt hay or threshed straw of wheat, rye, oats, or barley.
- B. Compost Mulch: Well-composted, stable, and weed-free organic matter, pH range of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through 1-inch sieve; soluble salt content of 5 to 10 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:
 - 1. Organic Matter Content: 50 to 60 percent of dry weight.
- C. Nonasphaltic Tackifier: Colloidal tackifier recommended by fiber-mulch manufacturer for slurry application; nontoxic and free of plant-growth or germination inhibitors.
- D. Asphalt Emulsion: ASTM D 977, Grade SS-1; nontoxic and free of plant-growth or germination inhibitors.

2.7 PESTICIDES AND HERBICIDES

- A. Pesticides: Registered and approved by EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.
- B. Pre-Emergent herbicide: Effective for controlling the germination of growth of weeds within planted areas at the soil level directly below the mulch layer.
- C. Post-Emergent Herbicide: Effective for controlling weed growth that has already germinated.

2.8 EROSION-CONTROL MATERIALS

- A. Erosion-Control Blankets: Biodegradable wood excelsior, straw, or coconut-fiber mat enclosed in a photodegradable plastic mesh. Include manufacturer's recommended steel wire staples.
- B. Erosion-Control Fiber Mesh: Biodegradable twisted jute or spun-coir mesh, a minimum of 0.92 lb/sq. yd., with 50 to 65 percent open area. Include manufacturer's recommended steel wire staples.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to receive turf and grass for compliance with requirements and other conditions affecting performance. Grade strictly according to the proposed grading plan. Proceed with installation only after Owner approves the subgrade and unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities, trees, shrubs, and plantings from damage caused by planting operations.
 - 1. Protect adjacent and adjoining areas from hydroseeding overspray.
- B. Provide 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.

3.3 TURF PREPARATION

- A. Limit turf subgrade preparation to areas to be planted.
- B. Newly Graded Subgrades: Loosen subgrade to a minimum depth of 8 inches. Remove stones larger than 1 inch in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.
 - 1. Spread 6" of topsoil and mix thoroughly into loosened subgrade.
 - 2. Spread 2" of soil conditioner (pine fines, organic compost, or organic soil builder), soil amendments and fertilizer on surface, and thoroughly blend planting soil mix to a depth of 6-8". Till soil to a homogeneous mixture of medium texture (some clumping is acceptable).
 - a. Delay mixing fertilizer with planting soil if planting will not proceed within a few days.
 - b. Mix lime with dry soil before mixing fertilizer.
 - c. Do not spread if planting soil, topsoil or subgrade is frozen, muddy or excessively wet
 - 3. Spread and rake smooth planting soil mix to meet finish grades after light rolling and natural settlement.
 - 4. Reduce elevation of planting soil to allow for soil thickness of sod.
- C. Unchanged Subgrades: If turf is to be planted in areas unaltered or undisturbed by excavating, grading, or surface soil stripping operations, prepare surface soil as follows:
 - 1. Remove existing grass, vegetation, and turf. Do not mix into surface soil.
 - 2. Loosen surface soil to a depth of 6 inches. Apply soil amendments and fertilizers according to planting soil mix proportions and mix thoroughly into top 6 inches of soil. Till soil to a homogeneous mixture of medium texture.

3. Remove stones larger than 1 inch in any dimension and sticks, roots, trash, and other extraneous matter.
 4. Legally dispose of waste material, including grass, vegetation, and turf, off Owner's property.
- D. Finish Grading: Grade planting areas to a smooth, uniform surface plane with loose, uniformly fine texture. Grade to within plus or minus 1/2 inch of finish elevation. Roll and rake, remove ridges, and fill depressions to meet finish grades. Limit fine grading to areas that can be planted in the immediate future.
- E. Moisten prepared turf areas before planting if soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.
- F. Restore areas if eroded or otherwise disturbed after finish grading and before planting.
- G. Before planting, obtain Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

3.4 SEEDING

- A. Sow seed with spreader or seeding machine. Do not broadcast or drop seed when wind velocity exceeds 5 mph. Evenly distribute seed by sowing equal quantities in two directions at right angles to each other.
1. Do not use wet seed or seed that is moldy or otherwise damaged.
- B. Sow seed at the rate recommended by seed manufacturer and as required to achieve 95% coverage over any 10 sq. ft.
- C. Rake seed lightly into top 1/8 inch of topsoil, roll lightly, and water with fine spray.
- D. Protect seeded areas with slopes exceeding 1:6 with erosion-control fiber mesh and 1:4 with erosion-control blankets installed and stapled according to manufacturer's written instructions.
- E. Protect seeded areas with slopes not exceeding 1:6 by spreading straw mulch. Spread uniformly at a minimum rate of 2 tons/acre to form a continuous blanket 1-1/2 inches in loose depth over seeded areas. Spread by hand, blower, or other suitable equipment.
1. Anchor straw mulch by crimping into topsoil with suitable mechanical equipment; Or
 2. Bond straw mulch by spraying with asphalt emulsion at the rate of 10 to 13 gal./1000 sq. ft. Take precautions to prevent damage or staining of structures or other plantings adjacent to mulched areas. Immediately clean damaged or stained areas.
- F. Protect seeded areas from hot, dry weather or drying winds by applying peat or compost mulch within 24 hours after completing seeding operations. Soak and scatter uniformly to a depth of 1/4 inch and roll to a smooth surface. Water daily or more frequently as necessary to maintain moist soil to a minimum depth of 2 inches.

3.5 HYDROSEEDING

- A. Hydroseeding: Mix specified seed, fertilizer, and fiber mulch in water, using equipment specifically designed for hydroseed application. Continue mixing until uniformly blended into homogeneous slurry suitable for hydraulic application.
1. Mix slurry with a tackifier.

2. Apply slurry uniformly to all areas to be seeded in a one-step process. Apply mulch at a minimum rate of 1500-lb/acre dry weight but not less than the rate required to obtain specified seed-sowing rate.

3.6 SODDING

- A. Remove plastic netting or backing from sod.
- B. Lay sod within 24 hours of harvesting. Do not lay sod if dormant, unless overseeded, or if ground is frozen or muddy.
- C. Lay sod to form a solid mass with tightly fitted joints. Butt ends and sides of sod; do not stretch or overlap. Stagger sod strips or pads to offset joints in adjacent courses. Avoid damage to subgrade or sod during installation. Tamp and roll lightly to ensure contact with subgrade, eliminate air pockets, and form a smooth surface. Work sifted soil or fine sand into minor cracks between pieces of sod; remove excess to avoid smothering sod and adjacent grass.
 1. Lay sod across angle of slopes exceeding 1:3.
 2. Anchor sod on slopes exceeding 1:6 with wood pegs or steel staples spaced as recommended by sod manufacturer but not less than 2 anchors per sod strip to prevent slippage.
- D. Saturate sod with fine water spray within two hours of planting. Water daily or more frequently as necessary to maintain moist soil to a minimum depth of 2 inches below sod.

3.7 TURF RENOVATION

- A. Renovate existing turf damaged by Contractor's operations, such as storage of materials or equipment and movement of vehicles.
 1. Reestablish turf where settlement or washouts occur or where minor regrading is required.
- B. Remove sod and vegetation from diseased or unsatisfactory turf areas; do not bury in soil.
- C. Remove topsoil containing foreign materials resulting from Contractor's operations, including oil drippings, fuel spills, stone, gravel, and other construction materials, and replace with new topsoil.
- D. Mow, dethatch, core aerate, and rake existing turf.
- E. Remove weeds before seeding. Where weeds are extensive, apply selective herbicides as required. Do not use pre-emergence herbicides.
- F. Remove waste and foreign materials, including weeds, soil cores, grass, vegetation, and turf, and legally dispose of them off Owner's property.
- G. Till stripped, bare, and compacted areas thoroughly to a soil depth of 6 inches.
- H. Apply soil amendments and initial fertilizers required for establishing new turf and mix thoroughly into top 4 inches of existing soil. Provide new planting soil to fill low spots and meet finish grades.
- I. Apply seed and protect with straw mulch as required for new turf.
- J. Water newly planted areas and keep moist until new turf is established.

3.8 TURF MAINTENANCE

- A. Maintain and establish turf by watering, fertilizing, weeding, mowing, trimming, replanting, and other operations. Roll, regrade, top-dress and replant bare or eroded areas and remulch to produce a uniformly smooth turf.
 1. In areas where mulch has been disturbed by wind or maintenance operations, add new mulch. Anchor as required to prevent displacement.
 2. Contractor shall maintain turf areas for a period of **90 days** from Substantial Completion.

- a. When initial maintenance period has not elapsed before end of planting season, or if turf is not fully established, continue maintenance during next planting season.
- B. Watering: Provide and maintain temporary piping, hoses, and turf-watering equipment to convey water from sources and to keep turf uniformly moist to a depth of 4 inches.
 1. Schedule watering to comply with the latest City of Raleigh Water Conservation Ordinance.
 2. Schedule watering to prevent wilting, puddling, erosion, and displacement of seed or mulch. Lay out temporary watering system to avoid walking over muddy or newly planted areas.
 3. Water turf at a minimum rate of 1 inch per week and document on Maintenance Report Form.
- C. Mow turf as soon as top growth is tall enough to cut. Repeat mowing to maintain specified height without cutting more than 33 percent of grass height. Remove no more than 33 percent of grass-leaf growth in initial or subsequent mowings. Do not delay mowing until grass blades bend over and become matted. Do not mow when grass is wet.
- D. When seeding must take place out-of-season for permanent grass, appropriate temporary seeding shall be done and the contractor shall be responsible for permanent seeding as specified in season at no additional cost to Owner. Do not allow temporary cover to grow over 12 inches in height before mowing.

3.9 PESTICIDE AND HERBICIDE APPLICATION

- A. Apply pesticides and other chemical projects and biological control agents in accordance with requirements of authorities having jurisdiction and the product label. Coordinate applications with owner's operations and others in proximity to the Work. Notify Owner before each application is performed.
- B. Post-Emergent Herbicide: Apply only as necessary to treat already-germinated weeds and in accordance with manufacturer's written recommendations.

3.10 CLEANUP AND PROTECTION

- A. Promptly remove soil and debris created by turf work from paved areas. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.
- B. Erect barricades and warning signs as required protecting newly planted areas from traffic. Maintain barricades throughout maintenance period and remove after turf is established.
- C. Remove erosion-control measures after grass establishment period.

END OF SECTION 329200

SECTION 329219 - SEEDING**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes:
 - 1. Fertilizing.
 - 2. Seeding.
 - 3. Mulching.
 - 4. Maintenance.

1.2 DEFINITIONS

- A. Weeds: Include Dandelion, Jimsonweed, Quackgrass, Horsetail, Morning Glory, Rush Grass, Mustard, Lambsquarter, Chickweed, Cress, Crabgrass, Canadian Thistle, Nutgrass, Poison Oak, Blackberry, Tansy Ragwort, Bermuda Grass, Johnson Grass, Poison Ivy, Nut Sedge, Nimble Will, Bindweed, Bent Grass, Wild Garlic, Perennial Sorrel, and Brome Grass. Additionally, the definition of weeds includes vegetative species other than specified species to be established in given area.

1.3 SUBMITTALS

- A. Section 013300 - Submittal Procedures: Requirements for submittals.
- B. Product Data: Submit data for seed mix, fertilizer, mulch, and other accessories.
- C. Manufacturer's Certificate: Certify Products meet or exceed specified requirements.

1.4 CLOSEOUT SUBMITTALS

- A. Section 017000 - Execution and Closeout Requirements: Requirements for submittals.

1.5 QUALITY ASSURANCE

- A. Provide seed mixture in containers showing percentage of seed mix, germination percentage, inert matter percentage, weed percentage, year of production, net weight, date of packaging, and location of packaging.
- B. Perform Work according to these Plans and authorities having jurisdiction.

1.6 QUALIFICATIONS

- A. Seed Supplier: Company specializing in manufacturing Products specified in this section with minimum three years documented experience.

- B. Installer: Company specializing in performing work of this section with minimum three years documented experience.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Section 016000 - Product Requirements: Product storage and handling requirements.
- B. Deliver grass seed mixture in sealed containers. Seed in damaged packaging is not acceptable.
- C. Deliver fertilizer in waterproof bags showing weight, chemical analysis, and name of manufacturer.

1.8 WARRANTY

- A. Time Period: Guarantee that all lawns and grasses shall be in a healthy and flourishing condition of active growth for the warranty period as specified in the Contract Agreement with the OWNER.
- B. Appearance During Warranty:
 - 1. Lawns: Shall be free of dead or dying patches, and all areas shall show foliage of a normal density, size, and color. Complete lush cover with no brown sections or cracks showing.
- C. Delays: All delays in completion of planting operations which extend the planting into more than one planting season shall extend the Warranty Period correspondingly.
- D. Exceptions: CONTRACTOR shall not be held responsible for failures due to neglect by OWNER, vandalism, etc., during Warranty Period. Report such conditions in writing.
- E. Replacements: Replace, without cost to OWNER, and as soon as weather conditions permit, all lawns and grasses not in a vigorous, thriving condition, as determined by Landscape Architect during and at the end of Warranty Period.

1.9 MAINTENANCE SERVICE

- A. Section 017000 - Execution and Closeout Requirements: Requirements for maintenance service.
- B. Maintain seeded areas immediately after placement until grass is well established and exhibits vigorous growing condition through the warranty period.

PART 2 - PRODUCTS

2.1 SEED MIXTURE

- A. Suppliers:
 - 1. Ernst Seeds (www.ernstseed.com)
 - 2. Pennington Seed (www.pennington.com)
 - 3. Or approved equal Substitutions: Section 016000 - Product Requirements.

- B. Furnish materials according to these Plan Drawings and authorities having jurisdiction.

2.2 SOIL MATERIALS

- A. Topsoil: Fertile, friable topsoil, typical for locality, capable of sustaining vigorous plant growth; free of subsoil, clay or impurities, plants, weeds and roots; pH within acceptable range for local planting; organic matter content between 4-12 percent of total dry weight. Additional soil characteristics within normal ranges as provided by soil test report.

2.3 SOIL AMENDMENT MATERIALS

- A. When soil tests indicate the need for soil amendment, apply soil conditioners or fertilizers to amend soil to specified conditions.
 - 1. Fertilizer: Containing 50 percent of elements derived from organic sources; of proportion necessary to eliminate deficiencies of topsoil, as indicated in analysis.
- B. Water: Clean, fresh, and free of substances or matter capable of inhibiting vigorous growth of plants.
- C. Herbicide: For pre-plant preparation, a broad-spectrum non-selective contact herbicide. For post-plant weed control, a granular or liquid-applied pre-emergent herbicide. Chemicals must be approved for use in the State of North Carolina and be applied by licensed applicators. The OWNERS' Representative must be notified at least 48 hours in advance of herbicide applications.
- D. Pesticide: Pesticides may be used for specific pest infestations, but only in limited application. Broad- spectrum insecticides applied over large portions of landscape will not be allowed. Chemicals must be approved for use in the State of North Carolina and be applied by licensed applicators. The OWNER and/or OWNERS' Representative must be notified at least 48 hours in advance of pesticide applications.

2.4 ACCESSORIES

- A. Mulching Material: As indicated on the drawings and in accordance with authorities having jurisdiction.
- B. Fertilizer: Commercial grade; recommended for grass; of proportion necessary to eliminate deficiencies of topsoil, as indicated in analysis or as indicated on the soil test report and in accordance with authorities having jurisdiction.
- C. Lime: As indicated on the drawings and in accordance with authorities having jurisdiction.
- D. Water: Clean, fresh and free of substances or matter capable of inhibiting vigorous growth of grass.
- E. Erosion Fabric: As indicated on the drawings and in accordance with authorities having jurisdiction.

2.5 SOURCE QUALITY CONTROL

- A. Section 014000 – Quality Requirements: Testing, inspection and analysis requirements.

- B. Provide recommendation for soil amendment application rates for specified seed mix as result of testing.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Section 013000 – Administrative Requirements: Verification of existing conditions before starting work.
- B. Verify prepared soil base is ready to receive the Work of this section.

3.2 PREPARATION

- A. Prepare subgrade in accordance with Section 312213.00 – Rough Grading.
- B. Once subsoil is lightly but firmly re-compacted, spread existing stockpiled topsoil over areas to be seeded to a 2-inch depth minimum after natural settlement occurs.
- C. Final Grading:
 - 1. Stones, Weeds, Debris: Verify that all areas to receive lawns (as indicated in Drawings) are clear of stones larger than 1 inch diameter, weeds, debris and other extraneous materials.
 - 2. Grades: Verify that grades are within 1 inch of the required finished grades. Verify that soil preparation and fertilization has been installed as required by soil testing. Report all variations in writing.
- D. Soil Moisture:
 - 1. Excessive Moisture: Do not commence work of this section when soil moisture content is so great that excessive compaction will occur, nor when it is so dry that dust will form in air or clods will not break readily.
 - 2. Inadequate Moisture: Apply water, as necessary, to bring soil to an optimum moisture content for planting.
- E. Apply soil amendments after smooth raking of topsoil and at application rate recommended by soil analysis.

3.3 SEEDING

- A. Apply seed at rate indicated on the Drawings, unless otherwise specified by manufacturer. Rake in lightly.
- B. Do not seed areas in excess of that which can be mulched on same day.
- C. Planting Season: The planting season shall be ideal for the type of planting specified on the Drawings.
- D. Do not sow immediately following rain, when ground is too dry, or when winds are over 12 mph.
- E. Immediately following seeding, apply mulch to thickness indicated on the Drawings. Maintain clear of shrubs and trees.

- F. Apply water with fine spray immediately after each area has been mulched. Saturate to 4 inches of soil.

3.4 SEED PROTECTION

- A. Cover seeded slopes where grade is 4 inches per foot or greater with erosion control fabric. Roll fabric onto slopes without stretching or pulling.
- B. Lay fabric smoothly on surface, bury top end of each section in 6-inch-deep excavated topsoil trench. Overlap edges and ends of adjacent rolls minimum 12 inches. Backfill trench and rake smooth, level with adjacent soil.
- C. Secure outside edges and overlaps at 36-inch intervals with stakes.
- D. Lightly dress slopes with topsoil to ensure close contact between fabric and soil.
- E. At sides of ditches, lay fabric laps in direction of water flow. Lap ends and edges minimum 6 inches.

3.5 MAINTENANCE

- A. Mow grass at intervals as required by manufacturer and/or Agreement with OWNER.
- B. Neatly trim edges and hand clip where necessary.
- C. Water to prevent grass and soil from drying out.
- D. Control growth of weeds with hand removal or use of organic, targeted herbicides.
- E. Immediately reseed areas showing bare spots.
- F. Repair washouts or gullies.
- G. Protect seeded areas with warning signs during maintenance period.

END OF SECTION 329219

SECTION 329300 - EXTERIOR PLANTS**PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Trees.
 - 2. Shrubs.
 - 3. Ground cover.
 - 4. Annuals and perennials.
- C. Related Sections include the following:
 - 1. Division 01 General Requirements
 - 2. Division 31 Earthwork.
 - 3. Division 32 Exterior Improvements.

1.3 DEFINITIONS

- A. Balled and Burlapped Stock: Exterior plants dug with firm, natural balls of earth in which they are grown, with ball size not less than diameter and depth recommended by ANSI Z60.1 for type and size of tree or shrub required; wrapped, tied, rigidly supported, and drum-laced as recommended by ANSI Z60.1.
- B. Container-Grown Stock: Healthy, vigorous, well-rooted exterior plants grown in a container with well-established root system reaching sides of container and maintaining a firm ball when removed from container. Container shall be rigid enough to hold ball shape and protect root mass during shipping and be sized according to ANSI Z60.1 for kind, type, and size of exterior plant required.
- C. Finish Grade: Elevation of finished surface of planting soil.
- D. Manufactured Topsoil: Soil produced off-site by homogeneously blending mineral soils or sand with stabilized organic soil amendments to produce topsoil or planting soil.
- E. Planting Soil: Standardized topsoil; existing, native surface topsoil; existing, in-place surface soil; imported topsoil; or manufactured topsoil that is modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.
- F. Root Flare: Also called "trunk flare". The area at the base of the plant's stem or trunk where the stem or trunk broadens to form roots; the area of transition between the root system and the stem or trunk. Root flare shall be set at grade.
- G. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or top surface of a fill or backfill, before placing planting soil.

- H. Subsoil: All soil beneath the topsoil layer of the soil profile, and typified by the lack of organic matter and soil organisms.
- I. Surface Soil: Soil that is present at the top layer of the existing soil profile at the Project site. In undisturbed areas, the surface soil is typically topsoil, but in disturbed areas such as urban environments, the surface soil can be subsoil.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated, including planting soil.
 - 1. Plant Materials: Include quantities, sizes, quality, and sources for plant materials.
 - 2. Pesticides and Herbicides: Include product label and manufacturer's application instructions specific to this Project. Comply with any City of Wilson restrictions or requirements.
- B. Sample of Verification:
 - 1. Nursery Sources: Submit a list of all nurseries that will supply plants, along with a list of the plants they will provide and the location of the nursery. Plants shall have been grown within the cold hardiness zone for the project site.
 - 2. Trees and Shrubs: Provide digital photos from the nursery with height identified (where applicable for trees) for review by Architect prior to digging. All trees and shrubs shall be reviewed, approved and tagged by Architect prior to arrival on site, either at place of purchase, nursery or holding yard. Contractor shall be responsible for the cost of travel associated with the plant material review, including time, mileage, meals and lodging, if necessary, incurred by Architect, unless approved otherwise by Owner.
 - 3. Mulch: 1 lb of each mulch required, in sealed plastic bags labeled with source of mulch. Sample shall be typical of the lot of materials to be delivered and installed on the site; provided an accurate representation of color, texture, and makeup of the material.
- C. Qualification Data: For landscape Installer. Include key personnel background and list of similar projects, minimum 3 projects completed and 5 years of experience in landscape installation by Installer demonstrating Installer's capabilities and experience. Include project names, addresses, and year completed, and include names and addresses of owners' contact persons.
- D. Material Test Reports: For existing surface soil and imported or manufactured topsoil.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: A qualified landscape installer shall be a licensed Landscape Contractor. Only a landscape Contractor as defined by the General Statutes of North Carolina and licensed in North Carolina shall be permitted to perform this work. A copy of the Landscape Contractor's License or License Number shall be presented to the Owner's representative at the time the contract is executed.
 - 1. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when exterior planting is in progress.
 - 2. Pesticide Applicator: State licensed, commercial.
 - 3. Trees shall be installed by or under the supervision of an ISA Certified Arborist or approved professional.

- B. Soil-Testing Laboratory Qualifications: An independent laboratory, recognized by the State Department of Agriculture, with the experience and capability to conduct the testing indicated and that specializes in types of tests to be performed.
- C. Soil Analysis: Furnish soil analysis by a qualified soil-testing laboratory stating percentages of organic matter; gradation of sand, silt, and clay content; cation exchange capacity; deleterious material; pH; and mineral and plant-nutrient content of the soil.
 - 1. Based on the test results, state recommended quantities of nitrogen, phosphorus, and potash nutrients and soil amendments to be added to produce satisfactory planting soil.
 - 2. Report presence of problem salts, minerals, or heavy metals, including aluminum, arsenic, barium, cadmium, chromium, cobalt, lead, lithium, and vanadium. If such problem materials are present, provide additional recommendations for corrective action.
- D. Provide quality, size, genus, species, quantity and variety/cultivar of exterior plants indicated, complying with applicable requirements in ANSI Z60.1, "American Standard for Nursery Stock."
- E. Tree and Shrub Measurements: Measure according to ANSI Z60.1 with branches and trunks or canes in their normal position. Do not prune to obtain required sizes. Take caliper measurements 6 inches above ground for trees up to 4-inch caliper size, and 12 inches above ground for larger sizes. Measure main body of tree or shrub for height and spread; do not measure branches or roots tip-to-tip.
- F. Observation and Rejection: Architect shall observe trees and shrubs at place of purchase, nursery holding yard, or at site before planting for compliance with requirements for genus, species, variety, size, and quality. Architect retains right to observe trees and shrubs further for size and condition of balls and root systems, insects, injuries, and latent defects and to reject unsatisfactory or defective material at any time during progress of work. Remove rejected trees or shrubs immediately from Project site.
- G. Substitutions:
 - 1. Substitutions for the listed plant material will be considered if the listed material cannot be located or confirmed by known suppliers. Plant suppliers must be researched and located prior to submittal. If plant material substitutions are to be made after award of the contract, the substitution must be of similar growth habit, form, and characteristics; similar in specified size; and subject to approval or rejection by the Owner's representative.
 - 2. If for any reason trees cannot be installed according to the plans, the Contractor shall inform the Owner prior to plant material delivery, and alternate planting locations shall be selected by the Owner's representative.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws if applicable.
- B. Bulk Materials:
 - 1. Do not dump or store bulk materials near structures, storm drains, utilities, walkways and pavements, or on existing turf areas or plants.
 - 2. Provide erosion control measures to prevent erosion or displacement of bulk materials, discharged of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.

3. Accompany each delivery of bulk fertilizers, lime, and soil amendments with appropriate certificates.
- C. Do not prune trees and shrubs before delivery, except as approved by Architect. Protect bark, branches, and root systems from sun scald, drying, sweating, whipping, and other handling and tying damage. Do not bend or bind-tie trees or shrubs in such a manner as to destroy their natural shape. Provide protective covering of exterior plants during delivery. Do not drop exterior plants during delivery.
- D. Handle planting stock by root ball. Heavier material shall be handled with straps on the root ball and appropriate equipment such as a small skid steer loader.
- E. Deliver bare-root stock plants freshly dug. Immediately after digging up bare-root stock, pack root system in wet straw, hay, or other suitable material to keep root system moist until planting.
- F. Store bulbs, corms and tubers in a dark dry place at 45-55 degrees F until planting.
- G. Deliver exterior plants after preparations for planting have been completed and install immediately. If planting is delayed more than six hours after delivery, set exterior plants in their appropriate aspect (sun, filtered sun, or shade), protect from weather and mechanical damage, and keep roots moist.
 1. Set balled stock on ground and cover ball with soil, peat moss, sawdust, or other acceptable material.
 2. Do not remove container-grown stock from containers before time of planting.
 3. Water root systems of exterior plants stored on-site with a fine-mist spray. Water as often as necessary to maintain root systems in a moist, but not overly-wet condition.
 4. Heel-in bare-root stock. Soak roots that are in dry condition in water for two hours. Reject dried-out plants.

1.7 COORDINATION

- A. Pre-Installation Conference: Arrange a pre-installation conference with the Architect and the Owner 2 weeks prior to the initiation of any planting activities.
- B. Planting Restrictions: Planting shall occur between the dates stated below. Coordinate planting periods with maintenance periods to provide required maintenance from date of Substantial Completion. Planting outside of the stated time periods can only occur with written approval from landscape architect, and might incur additional warranty and maintenance requirements.

1. B&B trees:	October 15 – March 15
2. Container-grown trees:	September 15 – April 15
3. Woody Shrubs:	September 15 – April 30
4. Warm-season Ornamental Grasses:	May 1 – September 30
5. Cool-season Ornamental Grasses:	September 15 – November 30
- C. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit.
- D. Coordination with Lawns: Plant trees and shrubs after finish grades are established and before planting lawns, unless otherwise acceptable to Architect.

1. When planting trees and shrubs after lawns, protect lawn areas and promptly repair damage caused by planting operations.

1.8 MAINTENANCE SERVICE

- A. Provide complete maintenance by skilled employees of landscape installer. Maintain as required in Part 3. Begin maintenance immediately after plants are installed and continue until plantings are acceptably healthy and well established for not less than 12 months from Substantial Completion.
- B. Maintenance Service: Submit to Owner on first day of month Maintenance Report Form (provided) showing weekly maintenance completed. Owner shall verify and sign off on Maintenance Report Form prior to maintenance payment.

1.9 WARRANTY

- A. Special Warranty: Warrant the exterior plants, for the warranty period indicated, against defects including death and unsatisfactory growth, except for defects resulting from neglect or abuse by Owner, or incidents that are beyond Contractor's control.
 1. Warranty Period for all plants: One year from date of Substantial Completion.
 2. Remove dead exterior plants immediately.
 3. Replace exterior plants that are more than 25 percent dead or in an unhealthy condition at end of warranty period during designated planting season or as directed by Owner.

PART 2 - PRODUCTS

2.1 PLANT MATERIAL

- A. General: Furnish nursery-grown plants true to genus, species, variety, cultivar, stem form, shearing, and other features indicated in Plant Schedule or Plant Legend shown on Drawings and complying with ANSI Z60.1, with healthy root systems developed by transplanting or root pruning. Provide well-shaped, fully branched, healthy, vigorous stock free of disease, insects, eggs, larvae, and defects such as knots, sun scald, injuries, abrasions, and disfigurement.
- B. Standards: All plant material and installation work shall conform to the standards detailed in the following documents including the latest additions and amendments:
 1. *American National Standards for Tree Care Operations, ANSI A300*. American National Standards Institute, 11 West 42nd Street, New York, N.Y. 10036
 2. *American National Standard for Nursery Stock, ANSI Z60.1*. American Nursery and Landscape Association, 1250 Eye Street. NW, Suite 500, Washington, D.C. 20005
 3. *Hortus Third*, The Staff of the L.H. Bailey Hortorium. 1976. MacMillan Publishing Co., New York
- C. Provide plants of sizes, grades, and ball or container sizes complying with ANSI Z60.1 for types and form of plants required. Plants of larger size may be used if acceptable to Architect, with a proportionate increase in size of roots or balls.

- D. Label each plant of each variety and caliper with a securely attached, waterproof tag bearing legible designation of botanical and common name. Include nomenclature for hybrid, variety, or cultivar, if applicable.
- E. All plant material shall be free of all pests, diseases, and cankers, in healthy condition, and free of mechanical damage at the time of planting.

2.2 PLANTING SOILS

- A. Planting soil: Refer to Specification 329200 – Turf and Grasses

2.3 INORGANIC SOIL AMENDMENTS

- A. Lime: ASTM C 602, agricultural limestone containing a minimum 80 percent calcium carbonate equivalent and as follows:
 - 1. Class: Class T, with a minimum 99 percent passing through No. 8 sieve and a minimum 75 percent passing through No. 60 sieve.
 - 2. Provide lime in form of dolomitic limestone.
- B. Sulfur: Granular, biodegradable, containing a minimum of 90 percent sulfur, with a minimum 99 percent passing through No. 6 sieve and a maximum 10 percent passing through No. 40 sieve.
- C. Sand: Clean, washed, natural or manufactured, free of toxic materials, particle size as approved by Architect.

2.4 ORGANIC SOIL AMENDMENTS

- A. Compost: Well-composted, stable, and weed-free organic matter, pH range of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through 3/4-inch sieve; soluble salt content of 5 to 10 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:
 - 1. Organic Matter Content: 50 to 60 percent of dry weight.
- B. Manure: Well-rotted, unleached, stable or cattle manure containing not more than 25 percent by volume of straw, sawdust, or other bedding materials; free of toxic substances, stones, sticks, soil, weed seed, and material harmful to plant growth.

2.5 FERTILIZER

- A. Bonemeal: Commercial, raw or steamed, finely ground; a minimum of 4 percent nitrogen and 20 percent phosphoric acid.
- B. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following composition:
 - 1. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing agency.
- C. Slow-Release Fertilizer: Granular or pelletized fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:
 - 1. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in

soil reports from a qualified soil-testing agency.

2. Fish-emulsion, compost tea.

- D. Other Organic Fertilizer: Contractor is encouraged to utilize other organic fertilizer with a lower nitrogen value, such as worm castings, sewage sludge. Contractor shall submit product information for Architect's approval prior to application.

2.6 MULCHES

- A. Organic Mulch: Free from deleterious materials and suitable as a top dressing of trees and shrubs, consisting of one of the following:

1. Type: Shredded hardwood; Ground or shredded bark; leaf mulch; Wood and bark chips.
2. Color: Natural.

- B. Compost Mulch: Well-composted, stable, and weed-free organic matter, pH range of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through 1-inch sieve; soluble salt content of 5 to 10 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:

1. Organic Matter Content: 50 to 60 percent of dry weight.

- C. Mineral Mulch: hard, durable stone, washed free of loam, sand, clay, and other foreign substances, of following type, size range, and color:

1. Type: Rounded riverbed gravel or smooth-faced stone, expanded slate or shale, lava rock, or other approved material as project site dictates.
2. Size Range: 2-4 inches.
3. Color: as approved by Architect.

2.7 PESTICIDES AND HERBICIDES

- A. Pesticides: Registered and approved by EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.
- B. Pre-Emergent herbicide: Effective for controlling the germination of growth of weeds within planted areas at the soil level directly below the mulch layer.
- C. Post-Emergent Herbicide: Effective for controlling weed growth that has already germinated.

2.8 STAKES AND GUYS

- A. Upright and Guy Stakes: Rough-sawn, sound, new hardwood, redwood, or pressure- preservative-treated softwood, free of knots, holes, cross grain, and other defects, 2 by 2 inches by length indicated, pointed at one end.
- B. Wood Deadmen: Timbers measuring 8 inches in diameter and 48 inches long, treated with specified wood pressure-preservative treatment.
- C. Flexible Ties: Wide rubber or elastic bands or straps, or arborist tape of length required to reach stakes or turnbuckles.

- D. Guy and Tie Wire: ASTM A 641/A 641M, Class 1, galvanized-steel wire, 2-strand, twisted, 0.106 inch in diameter.
- E. Guy Cable: 5-strand, 3/16-inch-diameter, galvanized-steel cable, with zinc-coated turnbuckles, a minimum of 3 inches long, with two 3/8-inch galvanized eyebolts.
- F. Hose Chafing Guard: Reinforced rubber or plastic hose at least 1/2 inch in diameter, cut to lengths required to protect tree trunks from damage.
- G. Flags: Standard surveyor's plastic flagging tape, 6 inches long.

2.9 LANDSCAPE EDGINGS

- A. Steel Edging: Standard commercial-steel edging, rolled edge, fabricated in sections of standard lengths, with loops stamped from or welded to face of sections to receive stakes.
 - 1. Edging Size: 1/8 inch wide by 6 inches deep.
 - 2. Stakes: Tapered steel, a minimum of 12 inches long.
 - 3. Accessories: Standard tapered ends, corners, and splicers.
 - 4. Finish: Zinc coated.
 - 5. Paint Color: Black.
- B. Aluminum Edging: Standard-profile extruded-aluminum edging, ASTM B 221 (ASTM B 221M), alloy 6063-T6, fabricated in standard lengths with interlocking sections with loops stamped from face of sections to receive stakes.
 - 1. Edging Size: 1/8 inch wide by 6 inches deep.
 - 2. Stakes: Aluminum, ASTM B 221, alloy 6061-T6, approximately 1-1/2 inches wide by 12 inches long.
 - 3. Finish: Black anodized.
 - 4. Paint Color: Black.

2.10 MISCELLANEOUS PRODUCTS

- A. Wood Pressure-Preservative Treatment: AWPAC2 with waterborne preservative for soil and freshwater use, acceptable to authorities having jurisdiction, and containing no arsenic, including ammoniacal copper arsenate, ammoniacal copper silicate, and chromated copper arsenate.
- B. Root Barrier: Black, molded, modular panels manufactured with 50 percent recycled polyethylene plastic with ultraviolet inhibitors, or herbicide impregnated fabric manufactured for this use.
- C. Burlap: Non-synthetic, biodegradable.
- D. Mycorrhizal Fungi: Dry, granular inoculant containing at least 5300 spores per lb of vesicular-arbuscular mycorrhizal fungi and 95 million spores per lb of ectomycorrhizal fungi, 33 percent hydrogel, and a maximum of 5.5 percent inert material.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to receive exterior plants for compliance with requirements and conditions affecting installation and performance. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities, and lawns and existing exterior plants from damage caused by planting operations.
- B. Provide 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.
- C. Lay out individual tree and shrub locations and areas for multiple exterior plantings. Stake locations, outline areas, adjust locations when requested, and obtain Architect's acceptance of layout before planting. Make minor adjustments as required.

3.3 PLANTING AREA ESTABLISHMENT

- A. Loosen subgrade of planting beds to a minimum depth of 9-12 inches prior to mixing amendments. Remove stones larger than 1 inch in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.
 - 1. Thoroughly blend planting soil mix by spreading topsoil, soil amendments, and fertilizer on surface, and thoroughly blend planting soil mix.
 - a. Delay mixing fertilizer with planting soil if planting will not proceed within a few days.
 - b. Mix lime with dry soil before mixing fertilizer.
 - 2. Spread 6" of topsoil and mix thoroughly into loosened subgrade.
 - 3. Spread 4" of soil conditioner (organic compost or organic soil builder), soil amendments and fertilizer on surface, and thoroughly blend planting soil mix to a depth of 8". Till soil to a homogeneous mixture of medium texture (some clumping is acceptable).
 - a. Delay mixing fertilizer with planting soil if planting will not proceed within a few days.
 - b. Mix lime with dry soil before mixing fertilizer.
 - c. Do not spread if planting soil, topsoil or subgrade is frozen, muddy or excessively wet
 - 4. Spread and rake smooth planting soil mix to meet finish grades after light rolling and natural settlement.
- B. Finish Grading: Grade planting beds to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.
- C. Restore planting beds if eroded or otherwise disturbed after finish grading and before planting.

3.4 TREE AND SHRUB EXCAVATION

- A. Pits and Trenches: Excavate circular pits with sides sloped inward. Trim base leaving center area raised slightly to support root ball and assist in drainage. Do not further disturb base. Scarify sides of plant pit smeared or smoothed during excavation.

1. Excavate approximately three times as wide as ball diameter for all stock or prepare entire planting bed.
 2. Pits shall be no deeper than the root flare of the tree or plant which shall be installed at grade, no higher than 2" above grade, and never below grade.
- B. Subsoil removed from excavations may be used as backfill provided it meets the specified planting soil mix requirements.
- C. Obstructions: Notify Owner if unexpected rock or obstructions detrimental to trees or shrubs are encountered in excavations.
- D. Drainage: Ensure tree pits drain within 24 hours. Notify Owner if subsoil conditions evidence unexpected water seepage or retention in tree or shrub pits.

3.5 TREE AND SHRUB PLANTING

- A. Set balled and burlapped stock plumb and in center of pit or trench with top of root ball 1-2 inches above adjacent finish grades.
1. Remove burlap and wire baskets from tops of root balls and top ½ of root ball, cut off and discard from hole, but do not remove from under root balls. Remove pallets, if any, before setting. Do not use planting stock if root ball is cracked or broken before or during planting operation.
 2. Place planting soil mix around root ball in layers, tamping gently to settle mix and eliminate voids and air pockets. When pit is approximately one-half backfilled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed. Water again after placing and tamping final layer of planting soil mix.
- B. Set container-grown stock plumb and in center of pit or trench with root flare at grade, no more than 2 inches above adjacent finish grades, and never below grade.
1. Carefully remove root ball from container without damaging root ball or plant. Gently loosen the roots and cut any girdling roots in at least two places.
 2. Place planting soil mix around root ball in layers, tamping to settle mix and eliminate voids and air pockets. When pit is approximately one-half backfilled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed. Water again after placing and tamping final layer of planting soil mix.
- C. Organic Mulching: Apply 3-inch average thickness of organic mulch extending 12 inches beyond edge of planting pit or trench and at a minimum radius of 2.5 feet from the trunk. Do not place mulch within 3 inches of trunks or stems. Root flare shall be visible at base of all plant material.

3.6 TREE AND SHRUB PRUNING

- A. Prune, thin, and shape trees and shrubs according to standard horticultural practice and ANSI A- 300 Pruning Standard. Unless otherwise indicated by Architect, do not cut tree leaders; remove only injured or dead branches from all plant material. Prune shrubs to retain natural character. Shrub sizes indicated are sizes after pruning.

3.7 ROOT PRUNING

- A. Area for root pruning shall be approved by Owner's representative.
- B. Acceptable methods of cutting are by sharp hand pruners, loppers, hand saw or hydraulic tools. Implement must leave a clean cut.
- C. If excavation causes pruned roots over 1.5" in diameter to remain exposed for more than 24 hours, roots on tree side shall be kept moist. Backfill with topsoil, moist mulch, or drape with wet burlap.
- D. Where concrete is poured adjacent to pruned roots, approved heavy duty plastic barrier shall be installed against the tree side of the pruned roots to prevent toxic uptake.

3.8 GUYING AND STAKING

- A. Upright Staking and Tying: Stake trees as directed by Owner. Stake trees of 2- through 5-inch caliper. Stake trees of less than 2-inch caliper only as required to prevent wind tip-out. Use a minimum of 3 stakes of length required to penetrate at least 18 inches below bottom of backfilled excavation and to extend 72 inches above grade. Set vertical stakes and space to avoid penetrating root balls or root masses. Support trees with two strands of tie wire encased in hose sections or arborist tape at contact points with tree trunk. Allow enough slack to avoid rigid restraint of tree. Space stakes equally around trees. No staking required in areas protected from excessive wind.
- B. Guying and Staking: Guy and stake trees exceeding 12 feet in height and more than 3 inches in caliper, unless otherwise indicated. Securely attach no fewer than 3 guys to stakes 30 inches long, driven to grade.
 - 1. Provide turnbuckles for each guy wire and tighten securely.
 - 2. Attach flags to each guy wire, one above turnbuckle and one 6 inches above finish grade.

3.9 GROUND COVER AND BULB PLANTING

- A. Set out and space ground cover and plants as indicated.
- B. Dig holes large enough to allow spreading of roots, and backfill with planting soil.
- C. Work soil around roots to eliminate air pockets and leave a slight saucer indentation around plants to hold water. Form saucers around shrubs over 36" on center and all trees.
- D. Water thoroughly after planting, taking care not to cover plant crowns with wet soil.

3.10 PLANTING BED MULCHING

- A. Mulch backfilled surfaces of planting beds and other areas indicated.
 - 1. Organic Mulch: Apply 3-inch average thickness of organic mulch, and finish level with adjacent finish grades. Do not place mulch against plant stems.

3.11 EDGING INSTALLATION

- A. Steel Edging: Install steel edging where indicated according to manufacturer's written instructions.
- B. Aluminum Edging: Install aluminum edging where indicated according to manufacturer's written instructions.

3.12 PLANT MAINTENANCE

- A. Maintenance Schedule: Weekly site visit, Monthly Report Form due to Owner
- B. Maintain plantings throughout maintenance period by pruning, cultivating, watering, weeding (beds and tree rings shall be maintained weed free), fertilizing, mulching, restoring planting saucers, adjusting and repairing tree-stabilization devices, resetting to proper grades or vertical position, and performing other operations as required to establish healthy, viable plantings. Spray or treat as required to keep plants free of insects and disease.
- C. Fill in as necessary soil subsidence that may occur because of settling, rutting or damage by equipment or other processes. Replace mulch materials damaged or lost in areas of subsidence.
- D. Apply treatments as required to keep plant materials, planted areas and soils free of pests and pathogens or disease. Use integrated pest management practices whenever possible to minimize the use of pesticides and reduce hazards. Treatments include physical controls such as hosing off foliage, mechanical controls such as traps, and biological control agents.
- E. Watering Instruction: Provide and maintain temporary piping, hoses, and watering equipment to convey water from sources.
 - 1. Watering volumes should be based upon delivery of 1 inch of moisture per week to the plant if precipitation does not meet that amount during the active growing season defined as April 1 through November 1.
 - 2. Supplemental water shall be applied during the establishment period as frequently as 3 times per week and during periods of drought or excessive heat.
 - 3. Use a slow flow hose end device and water each tree at the base for several minutes. Commercially available water bags are acceptable to ensure the root ball is soaked. All watering bags shall be removed from trees starting November 1 until April 1 of following year.
- F. For maintenance of landscape associated with stormwater devices, refer to Architect's Best Management Practice operation and maintenance manual.
- G. Mulch shall be refreshed at the end of the maintenance period, all stakes, ties, etc. removed at this time as well.

3.13 PESTICIDE AND HERBICIDE APPLICATION

- A. Apply pesticides and other chemical products and biological control agents in accordance with the product label. Coordinate applications with owner's operations and others in proximity to the Work. Notify Owner before each application is performed.

- B. Pre-Emergent Herbicide: Apply to tree, shrub and ground-cover areas in accordance with manufacturer's written recommendations. Do not apply to seeded areas.
- C. Post-Emergent Herbicide: Apply only as necessary to treat already-germinated weeds and in accordance with manufacturer's written recommendations.

3.14 CLEANUP AND PROTECTION

- A. During exterior planting, keep adjacent pavings and construction clean and work area in an orderly condition.
- B. Protect exterior plants from damage due to landscape operations, operations by other contractors and trades, and others. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged exterior planting.
- C. After installation and before Substantial Completion, remove nursery stakes, tie tape, labels, wire, burlap, and other debris from plant material, plantings, and Project site. Remove tree stabilization materials at the end of the maintenance period, or as approved by Architect. Nursery tags with species name shall remain until the end of the maintenance period.

3.15 DISPOSAL

- A. Disposal: Remove surplus soil and waste material, including excess subsoil, unsuitable soil, trash, and debris, and legally dispose of them off Owner's property.

END OF SECTION 329300

SECTION 331413 - PUBLIC WATER UTILITY DISTRIBUTION PIPING**PART 1 - GENERAL****1.1 SUMMARY****A. Scope of Work**

1. Furnish all labor, equipment, materials, and incidentals necessary to install and complete installation of potable water lines and appurtenances in accordance with the plans. All pipe and appurtenance material shall be of the type and class specified herein.
2. All pipeline and appurtenance excavation, bedding, pipe laying, jointing and coupling of pipe joints shall be completed as described herein.

B. Section Includes:

1. Pipe materials and fittings for public water distribution systems.
2. Tapping sleeves and valves.
3. Positive-displacement meters.
4. Pipe support systems.
5. Bedding and cover materials.

1.2 REFERENCE STANDARDS**A. American Society of Mechanical Engineers:**

1. ASME B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.

B. ASTM International:

1. ASTM A36/A36M - Standard Specification for Carbon Structural Steel.
2. ASTM A307 - Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength.
3. ASTM D1785 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
4. ASTM D2241 - Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series).
5. ASTM D3139 - Standard Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals.
6. ASTM F477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.

C. American Water Works Association:

1. AWWA C104 - Cement-Mortar Lining for Ductile-Iron Pipe and Fittings.
2. AWWA C105 - Polyethylene Encasement for Ductile-Iron Pipe Systems.
3. AWWA C110 - Ductile-Iron and Gray-Iron Fittings.
4. AWWA C111 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
5. AWWA C115 - Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges.
6. AWWA C151 - Ductile-Iron Pipe, Centrifugally Cast.
7. AWWA C153 - Ductile-Iron Compact Fittings.

8. AWWA C206 - Field Welding of Steel Water Pipe.
9. AWWA C600 - Installation of Ductile-Iron Mains and Their Appurtenances.
10. AWWA C605 - Underground Installation of Polyvinyl Chloride (PVC) and Molecularly Oriented Polyvinyl Chloride (PVCO) Pressure Pipe and Fittings.
11. AWWA C606 - Grooved and Shouldered Joints.
12. AWWA C900 - Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 In. Through 60 In., for Water Transmission and Distribution.

D. Manufacturers Standardization Society of the Valve and Fittings Industry:

1. MSS SP-60 - Connecting Flange Joints between Tapping Sleeves and Tapping Valves.

E. NSF International:

1. NSF 61 - Drinking Water System Components - Health Effects.
2. NSF 372 - Drinking Water System Components - Lead Content.

F. North Carolina Department of Transportation:

1. Standard Specifications for Roads & Structures, latest edition.

1.3 COORDINATION

A. Section 013000 - Administrative Requirements: Requirements for coordination.

B. Coordinate Work of this Section with utility Owner/Jurisdiction and Engineer.

C. Do not interrupt service to facilities occupied by Owner/Jurisdiction or others unless approved by the Engineer and Owner no fewer than 72 hours in advance of proposed interruption and after arranging to provide temporary water distribution service and fire flow protection.

1.4 SUBMITTALS

A. Section 013300 - Submittal Procedures: Requirements for submittals.

B. Product Data: Submit product technical information regarding pipe materials, pipe fittings, valves, hydrants, and other appurtenances.

C. Product technical information shall be furnished to the Engineer for his review and approval prior to installation of any materials. The Engineer may augment the technical information or product or request substitute products and technical information if, in his opinion, it will best serve the interest of the Owner/Jurisdiction.

D. Field Quality-Control Submittals: Indicate results of Contractor-furnished tests and inspections.

E. Preconstruction Photographs and/or Video: Submit digital files of photographs and/or video of Work areas and material storage areas in accordance with Section 013300.00 Submittal Procedures.

1.5 CLOSEOUT SUBMITTALS

A. Section 017000 - Execution and Closeout Requirements

- B. Project Record Documents: Record actual locations of piping, valves, connections, thrust restraints, and invert elevations.
- C. Identify and describe unexpected variations to subsoil conditions or discovery of uncharted utilities.

1.6 QUALITY ASSURANCE

- A. Perform Work according to 15A NCAC 18C.
- B. Valves: Mark valve body with manufacturer's name and pressure rating.
- C. Materials in Contact with Potable Water: Certified according to NSF 61 and NSF 372, including marking "NSF-pw" on piping.
- D. Perform Work according to the following requirements:
 - 1. Comply with all requirements of utility Owner including the tapping of water mains and backflow prevention.
 - 2. Comply with all standards of authorities having jurisdiction for potable water service piping, including materials, installation, testing, and disinfection.
 - 3. Comply with standards of authorities having jurisdiction for fire suppression water service piping, including materials, hose threads, installation, and testing.

1.7 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing products specified in this Section with minimum three years' documented experience.
- B. Installer: Company specializing in performing Work of this Section with minimum three years' documented experience in installation of liner materials.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Section 016000 - Product Requirements:
- B. Inspection: Accept materials on Site in manufacturer's original packaging and inspect for damage.
- C. Storage:
 - 1. Store materials according to manufacturer instructions.
 - 2. Block individual and stockpiled pipe lengths to prevent moving.
 - 3. Do not place pipe or pipe materials on private property or in areas obstructing pedestrian or vehicle traffic.
 - 4. Store PE and PVC materials out of sunlight.
- D. Protection:
 - 1. Protect materials from moisture and dust by storing in clean, dry location remote from construction operations areas.
 - 2. Plastic materials shall be supported to prevent sagging and bending.
 - 3. Plastic materials shall be covered with tarps.

4. Provide additional protection according to manufacturer instructions.

1.9 EXISTING CONDITIONS

A. Field Measurements:

1. Verify field measurements prior to fabrication.
2. Indicate field measurements on Shop Drawings.

PART 2 - PRODUCTS

2.1 WATER PIPING

A. General Requirements

1. All materials shall be first quality with smooth interior and exterior surfaces, free from cracks, blisters, honeycombs, and other imperfections, and true to industry-specified shapes and forms throughout. All materials shall be subject to the inspection of the Engineer at the plant, trench, or other point of delivery, for the purpose of culling and rejecting material which does not conform to the requirements of these specifications. Such material shall be marked by the Engineer, and the Contractor shall remove it from the project site upon notice being received of its rejection.
2. The use of couplings will not be allowed except as necessary and approved by the Engineer.
3. When the work requires the use of a transition coupling, the use of such couplings shall be as approved by the Engineer. When the nominal diameter of the pipe does not change, an approved transition coupling may be used, as necessary. In these cases, a ductile iron, mechanical joint, solid sleeve shall be used to join these materials. The solid sleeve shall be as specified for fittings and shall be the long body type. The appropriate gaskets shall be selected based on the outside diameter(s) of the material(s) being joined. All gaskets shall be as specified. In all cases, the gap between the pipe sections being joined shall not exceed 0.25 inches.
4. Where the nominal diameter of an existing water line changes as part of a rehabilitation project, an appropriate ductile iron, mechanical joint reducer, as specified for fittings, shall be used to joint these materials. The appropriate gaskets shall be selected based on the outside diameter(s) of the material(s) being joined. All gaskets shall be as specified.
5. All rubber gaskets for DIP pipe and fittings shall be in accordance with AWWA C111 and ASTM F477 for PVC pipe and fittings. All gaskets shall be a product of the pipe manufacturer, made specifically for the pipe being installed, and shall match the shape and configuration of the joint.
6. Gaskets
 - a. Gasket material shall be Styrene Butadiene Copolymer (SBR) unless otherwise noted.

B. Ductile-Iron Pipe:

1. Ductile iron pipe shall be of the size indicated on the Drawings and shall be in accordance with AWWA C150 and manufactured in accordance with AWWA C151.
2. Class numbers or pressure rating shall be clearly marked on the pipe and fittings at the factory.
3. Bituminous Outside Coating
 - a. All ductile iron pipe shall have an outside pipe coating of an asphaltic material a minimum of 1 mil thickness in accordance with AWWA C151. The final coat shall be continuous and smooth being neither brittle when subjected to low

- temperatures nor sticky when exposed to hot sun. The coating shall adhere to the pipe at all temperatures.
4. Pipe Mortar Lining (Interior Lining):
 - a. Line all ductile iron pipe and fittings with a cement mortar lining conforming to AWWA C104 except where other lining systems are specified by the Engineer.
 5. Joints:
 - a. Slip Joints (Push-on)
 - 1) Unless otherwise specified by the Engineer, pipe joints shall be slip-joint type.
 - 2) Comply with AWWA C111.
 - 3) Bells of "slip" joint pipe shall be contoured to receive a bulb-shaped circular rubber gasket, and plain ends shall have a slight taper to facilitate installation. The gasket and associated lubricant shall be furnished by the pipe manufacturer.
 - b. Mechanical Joints
 - 1) Comply with AWWA C111.
 - 2) Bolts for mechanical joints shall be high grade steel, low alloy type, with tee head and American Standard threads. Mechanical joint gland shall be ductile or gray iron and shall utilize a plain rubber gasket.
 - 3) Bolted mechanical pipe joints shall be used under all concrete structures and between all treatment structures for underground piping.
 - c. Flanged Joints
 - 1) Comply with AWWA C110, C115, and ASME B16.1.
 - 2) Flanged pipe shall have flanges with long hubs, shop fitted on the threaded end of the pipe.
 - 3) Where required, flanges shall be tapped for stud bolts. Flanges shall be accurately faced at right angles to the pipe axis and shall be drilled smooth and true, and covered with coal tar pipe varnish or otherwise protected against corrosion of flange faces. Flange faces shall be cleaned to bare metal with wire brushed before installation of pipe.
 - 4) Ductile iron flanged joint pipe shall be as specified by the Engineer. Pipe shall be ordered in lengths needed as no pipe shall be cut, threaded or flanged in the field. All pipe shall have Class 125 flanges unless otherwise specified.
 - 5) Flanged joints shall be made with through bolts of the required size. Bolts shall be zinc plated, with good and sound, well-fitting threads, so that the nuts may be turned freely by hand.
 - 6) Flanged joints shall be made up using only full-face gaskets with a minimum thickness of 1/8-inch. Ring gaskets are not acceptable. Gasket material shall be rubber or approved equal as recommended by the Manufacturer.
 - 7) Connecting flanges shall be in proper alignment and no external force shall be used to bring them together.
 - d. Restrained Joints
 - 1) Restrained joints shall be the boltless type to include ductile iron locking segments and rubber retainers.
 - 2) Restrained pipe and fittings shall be one of the following, or approved equal, as allowed by authorities with jurisdiction:

Manufacturer	Product
American Cast Iron Pipe Company	Fast-Grip Gasket
McWane Ductile	Sure Stop 350 Gasket
US Pipe	Field Lok 350 Gasket
American Cast Iron Pipe Company	MJ Coupled Joint
McWane Ductile	MJ Lock Joint
US Pipe	Bolt-Lok

American Cast Iron Pipe Company	Lok-Ring
McWane Ductile	Flex-Ring
US Pipe	TR Flex

- C. Pressure Class Polyvinyl Chloride (PVC) Pipe
1. Comply with AWWA C900 (4" through 60") DR18 or DR14.
 2. Fittings shall be ductile iron mechanical joint as described herein.
 3. Joints:
 - a. The pipe shall have bell and spigot ends with push-on, O-ring rubber gasket, compression type joints meeting the requirements of ASTM D3139 and ASTM F477.
 - b. The lubricant used in making up the joints shall be furnished by the pipe manufacturer and shall be NSF approved.
 - c. Solvent-cement couplings are only permitted on above ground or exposed piping where specified by the Engineer. Solvent cement shall conform to ASTM D2564.
- D. PVC: Pressure Rated PVC
1. Comply with ASTM D2241.
 2. Maximum diameter: 12" nominal.
 3. Pressure Class: Minimum allowable rating and thickness shall be Pressure Rating 200, SDR 21. Sustained pressure and quick-burst pressure testing requirements shall be in accordance with ASTM 1598 and ASTM 1599, respectively.
 4. The exterior of all PVC Pipe shall bear a stamp which shows the AWWA certification, SDR, size and NSF seal.
 5. Fittings shall be ductile iron mechanical joint as described herein.
 6. Joints:
 - a. The pipe shall have bell and spigot ends with push-on, O-ring rubber gasket, compression type joints meeting the requirements of ASTM D3139 and ASTM F477.
 - b. The lubricant used in making up the joints shall be furnished by the pipe manufacturer and shall be NSF approved.
 - c. Seals: PVC flexible elastomeric.
 - d. Solvent-cement couplings are not permitted.
- E. PVC: Scheduled PVC
1. Scheduled PVC shall be used only in above ground, interior plumbing.
 2. Comply with ASTM D1784 and D1785.
 3. Schedule: 40, 80, or as shown on the Drawings.
 4. Fittings shall be ductile iron mechanical joint as described herein.
 5. Joints:
 - a. The pipe shall have bell and spigot ends with push-on, O-ring rubber gasket, compression type joints meeting the requirements of ASTM D3139 and ASTM F477.
 - b. The lubricant used in making up the joints shall be furnished by the pipe manufacturer and shall be NSF approved.
 - c. Solvent-cement couplings are only permitted on above ground or exposed piping. Solvent cement shall conform to ASTM D2564.

2.2 FITTINGS

- A. General
1. All fittings for any type of water distribution piping shall be ductile iron.

2. All fittings shall be installed per manufacturer's installation instructions. This may include the removal of spacers depending upon the pipe material.
 3. Compact mechanical joint fittings shall be used for subsurface installations and compact flanged fittings shall be used for above-ground installations.
 4. Coating and Lining:
 - a. Bituminous Coating: Comply with AWWA C110.
 - b. Cement-Mortar Lining: Comply with AWWA C104.
- B. 2" Ductile Iron Fittings
1. Material: Grade 65-45-12 ductile iron in accordance with ASTM A536. Fittings shall have deep bell push-on joints with gaskets meeting ASTM F477. Transition gaskets are not allowed.
- C. 3" through 64" Ductile Iron Fittings
1. Material: Ductile iron; comply with AWWA C110.
 2. Compact Fittings (mechanical joint and flanged): Comply with AWWA C153.

2.3 UNDERGROUND PIPE LOCATION

- A. Warning Tape
1. Provide and install an early warning detection tape above all underground piping.
 2. Tape shall be 3" wide by 4 mils thick. Tape shall be solid blue in color with continuously printed caption in black letters "CAUTION – BURIED WATER LINE BELOW". Tape shall have a minimum tensile strength in accordance with ASTM D882.
 3. Install approximately 18" below ground and directly over pipeline.
- B. Tracer Wire
1. Where specified, provide and install tracer wire meeting the following.
 - a. Wire shall be a minimum #14 AWG high strength copper clad steel conductor wire secured to the pipe at 10' maximum spacing and rated for direct burial use at 30 volts.
 - b. Wire shall be insulated with 30 mil, high density, high molecular weight polyethylene (HDPE).
 - c. Wire break load shall be a minimum 250 lbs.
 - d. Install wire at the 12 o'clock position, directly atop the pipeline.
- C. Tracer Wire Access Point
1. A tracer wire testing station shall be installed in every valve box.

2.4 PIPE SUPPORTS AND ANCHORING

- A. Metal for Pipe Support Brackets:
1. Material: Structural steel.
 2. Finish: Galvanized.
 3. Coating: Bituminous paint.
- B. Metal Tie Rods and Clamps or Lugs:
1. Material: Stainless steel.

2.5 CONCRETE ENCASEMENT AND CRADLES

- A. Concrete:

1. Concrete design: As specified.
2. Type: Reinforced, air entrained.
3. Compressive Strength: 4,000 psi at 28 days.
4. Finish: Rough troweled.
5. Reinforce concrete as specified.

2.6 MATERIALS

A. Bedding and Backfill:

1. General: No rock, boulders, stone or debris larger than four inches shall be allowed in the bedding or backfill material. Deficient or unsuitable bedding or backfill material shall be replaced or substituted with suitable bedding or backfill material. Excavated material intended for use as bedding or backfill shall not be used if exceedingly wet nor shall trenches be backfilled if flooded or excessively wet.
2. Stone: Stone used for pipe bedding and trench stabilization shall meet the gradation requirements of standard aggregate size No. 67.
3. Soil: Soils for bedding and backfill are described in the ASTM D2487 Figure 1 soils classification chart, and, for purposes of these Specifications, are grouped into five (5) categories as follows, according to their suitability
 - a. Class I Soil - Angular, 6 to 40 mm ($\frac{1}{4}$ " to $1\frac{1}{2}$ "), graded stone, including a number of fill materials that have regional significance, such as coral, slag, cinders, crushed stone, and crushed shells.
 - b. Class II Soil - Coarse sands and gravels with maximum particle size of 40 mm ($1\frac{1}{2}$ "), including variously graded sands and gravels containing small percentages of fines, generally granular and non-cohesive, either wet or dry. Soil types GW, GP, SW, and SP are included in this class.
 - c. Class III Soil - Fine sand and clayey gravels, including fine sands, sand clay mixtures, and gravel clay mixtures. Soil types GM, GC, SM, and SC are included in this class.
 - d. Class IV Soil - Silt, silty clays, and clays, including inorganic clays and silts of medium to high plasticity and liquid limits. Soil types MH, ML, CH, and CL are included in this class. These materials are not recommended for bedding, haunching, or initial backfill.
 - e. Class V Soil - Includes the organic soils types OL, OH, and PT, as well as soils containing frozen earth, debris, rocks larger than $1\frac{1}{2}$ inches in diameter, and other foreign materials. These materials are not recommended for bedding, haunching, or initial backfill for any of the accepted pipe materials.

2.7 ACCESSORIES

- ### A. Steel Rods, Bolt, Lugs, and Brackets:
1. Comply with ASTM A36 and A307.
 2. Grade A carbon steel.

PART 3 - EXECUTION

3.1 EXAMINATION

- #### A. Section 017000 - Execution and Closeout Requirements: Requirements for installation examination.

- B. Verify that existing utility water main size, location, and invert are as indicated on Drawings.
- C. Existing Utilities
 - 1. The Contractor shall be required to excavate to determine the precise location of utilities or other underground obstructions which are shown on the Plans and/or marked by the utility owners. Such location and excavation shall be performed prior to installation of the pipeline.
 - 2. The Contractor shall notify all utility owners prior to excavation as required by the 1985 Underground Damage Prevention Act. Utility owners who are members of NC 811 may be notified by calling 811 (toll free) before any excavation or drilling. The Contractor will be fully responsible for damage to any utilities if the Owners have not been properly notified as required by the Underground Damage Prevention Act. All damage to such structures and pipelines and all damage to property or persons resulting from damage to such structures and pipelines shall be borne by the Contractor and shall be completely repaired within a reasonable time. No claim shall be made against the Owner for damage or delay of the work on account of the proximity of, or the leakage from, such structures and pipelines. Where high pressure gas lines are to be crossed, they shall be uncovered by hand excavation methods before other excavation near them is started.
 - 3. Utility Owners may, at their option, have representatives present to supervise excavation in the vicinity of their utilities. The cost of such supervision, if any, shall be borne by the Contractor.
 - 4. Conflicts with underground utilities may necessitate changes in alignment and/or grade of this construction. The Contractor shall notify the Engineer promptly upon the discovery of such conditions. Changes in alignment and/or grade shall be approved by the Engineer before construction may proceed.
 - 5. When underground obstructions not shown on the Plans are encountered, the Contractor shall promptly report the conflict to the Engineer and shall not proceed with construction until the conflict is resolved.

3.2 PREPARATION

- A. Preconstruction Site Documentation shall be in accordance with Section 013300.00 – Submittal Procedures.
- B. Pipe Cutting:
 - 1. Cut pipe ends square, ream pipe and tube ends to full pipe diameter, and remove burrs.
 - 2. Use only equipment specifically designed for pipe cutting; use of chisels or hand saws is not permitted.
 - 3. Grind edges smooth with beveled end for push-on connections.
 - 4. In the case of slip joint pipe, the cut ends shall be tapered with a portable grinder or coarse file to match the manufactured taper.
- C. Remove scale and dirt on inside and outside of pipe before assembly.
- D. Prepare pipe connections to equipment in accordance with equipment manufacturer's requirements.

3.3 INSTALLATION

- A. General:
 - 1. Pipe and fittings shall be laid as shown on the Drawings.

2. Contractor shall provide all materials, labor, tools, equipment and incidentals required for the excavation, installation, backfilling and testing of water mains and associated appurtenances.
 3. Do not use flanged pipe, fittings, or valves or unions for underground (buried) piping. Fittings and valves for underground (buried) piping shall be mechanical joint. Flanged pipe, fittings and valves and unions shall be used on aboveground piping and piping in vaults.
 4. Transition couplings and special fittings with pressure ratings at least equal to piping pressure rating may be used as specified, unless otherwise indicated.
 5. All pipe fittings, valves, hydrants and accessories shall be carefully lowered into the trench with suitable equipment in a manner that will prevent damage to pipe and fittings. Under no circumstances shall pipe or accessories be dropped or dumped into the trench. Any defective, damaged, or unsound material shall be repaired or replaced as directed by the Engineer.
- B. Bedding and Backfill:
1. General:
 - a. Place bedding material to the level shown on the Drawings.
 - b. Work material carefully around the pipe to ensure adequate haunching.
 - c. Minimum cover on pipes shall be 3 feet, unless otherwise required by authorities with jurisdiction.
 2. PVC Pipe:
 - a. After excavation is completed, bed with 4" of Class I, Class II, or No. 67 stone material to bring trench bottom to grade. Excavated native material may be used if material conforms to this specification.
 - b. After the joint has been made, backfill to spring line of pipe with Class I, Class II, or No. 67 stone material. Additional bedding requirements are outlined in project drawings and shall be followed.
 3. Ductile Iron Pipe:
 - a. After excavation and the joint has been made, bed with 4" of Class I, II, III, or IV bedding material. This may be the native trench bottom if material conforms to this specification.
 - b. Compact backfill by hand tamping under the haunches of the pipe barrel to assure a firm circular bearing surface for the pipe taking care not to move or raise the pipe or in any way create a non-uniform bearing surface. Additional bedding requirements outlined in project drawings and shall be followed.
 4. Compaction:
 - a. Backfill in 6- to 12-inch lifts. Tamp each lift carefully and uniformly so as to eliminate the possibility of lateral displacement of the pipeline.
 - b. Compact pipe bedding and embedment material to 95% Standard Proctor.
- C. Piping:
1. Comply with AWWA C600, C605, M41, and M23.
 2. Handle and assemble pipe according to manufacturer instructions.
 3. Steel Rods, Bolts, Lugs, and Brackets: Coat buried steel before backfilling.
 4. Pipe Separation
 - a. Lateral Separation of Sewers and Water Mains
 5. Maintain 10 feet of horizontal separation between water main and sewer piping.
 - a. If local conditions or barriers prevent a 10-foot separation:
 - 1) The water main shall be laid in a separate trench with the elevation of the bottom of the water main at least 18 inches above the top of the sewer; or
 - 2) The water main shall be laid in the same trench as the sewer with the water main located at one side on a bench of undisturbed earth, and with the elevation of the bottom of the water main at least 18 inches above the top of the sewer.
 - b. Crossing a Water Main over a Sewer

- 1) The water main shall be laid at such an elevation that the bottom of the water main is at least 18 inches above the top of the sewer, unless local conditions or barriers prevent an 18 inch vertical separation in which case both the water main and sewer shall be constructed of ferrous materials and with joints that are equivalent to water main standards for a distance of 10 feet on each side of the point of crossing.
 - c. Crossing a Water Main under a Sewer
 - 1) Both the water main and the sewer shall be constructed of ferrous materials and with joints equivalent to water main standards for a distance of 10 feet on each side of the point of crossing. A section of water main pipe shall be centered at the point of crossing.
 - d. Crossing a Storm Sewer
 - 1) All water lines shall have a minimum 12 inches of vertical separation from storm sewers.
6. Pipe Insulation
 - a. All outdoor piping 4" in diameter and smaller which is not buried shall be insulated except where specifically stated otherwise on the Drawings or in these specifications.
 - b. Provide heat tape and controls as recommended by manufacturer for temperatures down to -10° f. This requirement shall also apply to piping in vaults.
 - c. The piping shall be insulated with 1" thick polyfoam with the insulation laminated to an outside jacket of PVC with a finished color of white. The material shall be furnished in standard 25' rolls with insta-grip closure.
 - d. Fittings and valves shall be insulated with preformed white insulated fitting covers with 1" thick polyurethane foam insert.
 - e. Pipe insulation shall be wrapped around pipe and trac locked down in position. Insulation shall be held in place by sealing trac with fastener-weld or equal.
 - f. All butt joints and fitting covers shall be sealed with silicone sealant and then taped in place to provide a vapor barrier.
 - g. Installation procedures and accessory materials shall all be in accordance with the pipe insulation manufacturer's written instructions.
7. Connection to Existing Water Main/System
 - a. The Contractor shall make connection to the old mains when and as directed by the Engineer. In no case shall the Contractor shut off the water or operate the fire hydrants or gate valves of the old distribution system. In case it becomes necessary to delay the cut-off, such instructions shall be given and obeyed without recourse. At no time shall the Contractor operate any valves, gates, pumps, etc. All of these operations must be done by Owner's personnel.
 - b. In making connections to the old distribution system, valves shall be set as shown on the plans or at such designated place as the Engineer may direct. If due to unforeseen conditions, these locations have to be changed or additional valves or fittings added, the Contractor shall install the valves or fittings at the new locations upon approval by the Engineer. Payment for special fittings or couplings will not be made unless approved by the Engineer prior to installation.
 - c. The Contractor shall be responsible for determining and utilizing all measures required by the water utility Owner in tapping existing water mains. The Contractor shall also make appropriate arrangements with the water utility Owner based on the size and location of the tap indicated on the drawings.
 - d. If the proposed water extension does not begin at an existing valve, a new tapping sleeve and valve of the size specified shall be installed at the required location as specified. All tapping sleeves and valves shall be installed in accordance with MSS SP-60. Alternately, if water service interruption is acceptable to the Owner, a valve may be installed at the appropriate location in the existing water piping.
 - e. The Contractor shall be responsible for installing all backflow prevention devices or other "jumpers" as may be required by the Plans or the water utility Owner at the point of connection with the existing water system. For extensions of the existing

system, the valve isolating the new system from the existing system will not be opened until all other water system construction has been completed and satisfactorily passed all testing in compliance with these specifications unless specifically authorized by the water utility Owner.

8. Thrust Block Installation
 - a. All turns, fittings, etc., that induce pressure which would cause separation of pipe, break-age, etc., shall be provided with adequate thrust blocks, unless otherwise shown on the drawings. Thrust blocks shall be constructed to the minimum dimensions shown on the drawings or as directed by the Engineer.
 - b. Thrust blocks shall be made of ready mix concrete with a minimum compressive strength at 28 days of not less than 3,000 PSI when tested in accordance with ASTM C39. Sakrete or any similar material will not be permitted under any circumstances.
 - c. Blocking shall be formed and placed in such a manner that the pressure to be exerted at the point of blocking shall be transferred to firm, undisturbed earth. Where possible, the concrete shall be placed so that the fitting joints will be accessible for repair.
 - d. All bolts and pipe joints shall be protected against contact with thrust block concrete by the installation of a 20 mil polyethylene film placed between the fittings and the concrete. Where any section of a main is provided with concrete thrust blocks, the hydrostatic pressure test shall not be made until seven days after installation of the concrete thrust blocks unless otherwise approved by the Engineer. Where trench conditions are, in the opinion of the Engineer, unsuitable for thrust blocks, the Contractor shall provide steel tie rods and socket clamps to adequately anchor the piping. All tie rods and clamps shall be given a bituminous protective coating or shall be galvanized.
 - e. The Contractor shall also be responsible for any damage or repairs caused by blow-outs of any insufficiently blocked pipe.
9. Joint Construction
 - a. All pipe joints shall be constructed in strict accordance with the pipe manufacturer's specifications and materials and any deviation must have prior approval of the Engineer.
 - b. The maximum deflection per joint of flexible joint pipe shall be that deflection recommended by the manufacturer. However, at no time will a deflection greater than 3 degrees (11 inches in an 18'-0" pipe section) be allowed.
 - c. Mechanical Joints
 - 1) Clean last 8-inches outside the spigot, and the inside of the bell of mechanical joint pipe to remove oil, grit, tar (other than standard coating) and other foreign matter from the joint and then paint area clean with an approved soap solution. The ductile iron gland shall then be slipped on the spigot end of the pipe with the extension of the gland toward the socket or bell end. The rubber gasket shall be painted with the soap solution and placed on the spigot end with thick edge toward the gland.
 - 2) Push entire section of pipe forward to seat spigot end in the bell. Press gasket into place within the bell, being careful to have the gasket evenly located around the entire joint. Move ductile iron gland along the pipe into position for bolting, insert all bolts and screw nuts up tightly with fingers. Tighten all nuts with a suitable (preferably torque-limiting) wrench. Tighten nuts that are spaced 180 degrees apart alternately in order to produce equal pressure on all parts of the gland. If effective sealing is not obtained by tightening the bolts to the specified torques, the joint shall be disassembled and reassembled after thorough cleaning.
 - 3) An adapter having a fitting bell and a mechanical joint socket may be used by the Contractor when joining an existing bell and spigot to a new mechanical joint.
 - d. Push-on Joints

- 1) Clean gasket and spigot and inside of bell thoroughly to remove all dirt and other foreign matter.
- 2) Insert gasket furnished by the pipe manufacturer into the gasket groove in the bell. Gasket shall be properly seated in the grooves provided in the pipe bell.
- 3) Using a non-toxic vegetable soap, apply a film by hand to the inside surface of the gasket that comes into contact with the entering pipe and to the first 1" of the spigot end of the entering pipe. Use only lubricant specified by the pipe manufacturer.
- 4) Align entering pipe with the bell to which it is to be joined. Enter the spigot end into the bell until it just makes contact with the gasket. Apply sufficient pressure to force the spigot end past the gasket up to solid contact with the bell.
- 5) When it is necessary to field cut pipe with rubber gaskets, chamfer the cut end 1/8 inch x 30 degrees and check for roundness before inserting into a rubber gasket bell.
- e. Copper Joints: Pressure-sealed joints for copper tubing shall be made using proprietary crimping tool and procedure recommended by copper, pressure-seal-fitting manufacturer.
10. Ductile-Iron Piping and Fittings: Comply with AWWA C600.
11. Grooved and Shouldered Pipe Joints: Comply with AWWA C606.
12. Field Welding Materials: Comply with AWWA C206.
13. Exposed Piping
 - a. All exposed piping to be installed inside tanks, wetwells, vaults and buildings shall be installed as shown on the Drawings. All exposed pipe shall be ductile iron utilizing flanged joints unless otherwise noted.
 - b. All exposed ductile iron pipe, fittings and valves shall be field painted with two (2) coats of epoxy paint as recommended by the paint manufacturer. Color of paint shall be as selected by the Owner.
14. No pipe shall be laid except in the presence of the Engineer or his Representative or with special permission from the Engineer.
15. Route pipe in straight line, and re-lay pipe that is out of alignment or grade.
16. Pipe shall be removed at any time if broken, injured or displaced in the process of laying same, or of backfilling the trench.
17. High Points:
 - a. Pipe shall be installed in a manner that minimizes localized high points in the piping.
 - b. If unforeseen field conditions arise that necessitate high points, install air-release valves as specified, as indicated on Drawings, or as directed by the Engineer.
18. Bearing:
 - a. Maintain bearing along entire length of pipe.
 - b. Excavate bell holes to permit proper joint installation.
 - c. Do not lay pipe in wet or frozen trench.
19. Prevent foreign material from entering pipe during placement.
20. Allow for expansion and contraction without stressing pipe or joints.
21. Close pipe openings with watertight plugs during Work stoppages.
22. Establish elevations of buried piping with not less than 3 feet of cover.
 - a. Measure depth of cover from final surface grade to top of pipe barrel.
- D. PE Encasement:
 - a. Encase piping in PE where indicated to prevent contact with surrounding backfill material.
 - b. Comply with AWWA C105.
 - c. Terminate encasement 3 to 6 inches above ground where pipe is exposed.
- E. Backfilling: Backfill around sides and to top of pipe as specified.

3.4 FIELD QUALITY CONTROL

- A. Testing: Pressure test and disinfect as specified.

END OF SECTION 331413

SECTION 331417 - SITE WATER SERVICE UTILITY LATERALS**PART 1 - GENERAL****1.1 SUMMARY****A. Section Includes:**

1. Pipe and fittings for water service connections to buildings at the type and size indicated on the Plan Drawings.
2. Corporation stop assemblies.
3. Curb stop assemblies.
4. Backflow preventers.
5. Meter setting equipment.
6. Meter boxes.
7. Trenching, bedding, and cover.

1.2 REFERENCE STANDARDS**A. American Society of Mechanical Engineers:**

1. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings.

B. American Society of Sanitary Engineering:

1. ASSE 1012 - Performance Requirements for Backflow Preventers with an Intermediate Atmospheric Vent.
2. ASSE 1013 - Performance Requirements for Reduced Pressure Principle Backflow Preventers and Reduced Pressure Principle Fire Protection Backflow Preventers.

C. ASTM International:

1. ASTM B62 - Standard Specification for Composition Bronze or Ounce Metal Castings.
2. ASTM B88 - Standard Specification for Seamless Copper Water Tube.
3. ASTM D698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³ (600 kN-m/m³).
4. ASTM D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft³ (2,700 kN-m/m³).
5. ASTM D1785 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
6. ASTM D2241 - Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series).
7. ASTM D2466 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
8. ASTM D2855 - Standard Practice for the Two-Step (Primer and Solvent Cement) Method of Joining Poly (Vinyl Chloride) (PVC) or Chlorinated Poly (Vinyl Chloride) (CPVC) Pipe and Piping Components with Tapered Sockets.
9. ASTM D6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

D. American Water Works Association:

1. AWWA C509 - Resilient-Seated Gate Valves for Water Supply Service.
2. AWWA C600 - Installation of Ductile-Iron Mains and Their Appurtenances.
3. AWWA C800 - Underground Service Line Valves and Fittings.
4. AWWA C901 - Polyethylene (PE) Pressure Pipe and Tubing, 1/2 In. (13 mm) Through 3 In. (76 mm), for Water Service.
5. AWWA M6 - Water Meters - Selection, Installation, Testing, and Maintenance.

1.3 SUBMITTALS

- A. Section 013300 - Submittal Procedures: Requirements for submittals.
- B. Product Data: Submit manufacturer information regarding pipe materials, pipe fittings, corporation stop assemblies, curb stop assemblies, meters, meter setting equipment, service saddles, backflow preventers, and accessories.
- C. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.
- D. Manufacturer Instructions: Submit detailed instructions on installation requirements, including storage and handling procedures.
- E. Field Quality-Control Submittals: Indicate results of Contractor-furnished tests and inspections.
- F. Qualifications Statement:
 1. Submit qualifications for manufacturer.

1.4 CLOSEOUT SUBMITTALS

- A. Section 017000 - Execution and Closeout Requirements.
- B. Project Record Documents: Record actual locations of service lines, curb stops, connections, thrust restraints, pressure-pipe centerline elevations, and gravity-pipe invert elevations.
- C. Identify and describe unexpected variations to subsoil conditions or discovery of uncharted utilities.

1.5 QUALITY ASSURANCE

- A. Perform Work in accordance with authorities having jurisdiction.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Section 016000 - Product Requirements.
- B. Inspection: Accept materials on Site in manufacturer's original packaging and inspect for damage.
- C. Store materials according to manufacturer instructions.
- D. Protection:

1. Protect materials from moisture and dust by storing in clean, dry location remote from construction operations areas.
2. Provide additional protection according to manufacturer instructions.

PART 2 - PRODUCTS

2.1 WATER PIPING AND FITTINGS

- A. All water service piping shall be copper tubing unless otherwise stated in the Drawings.
- B. Direct taps without the use of fittings or saddles shall not be allowed on PVC or HDPE water mains. Direct taps in DIP water mains shall be performed using a corporation stop of equal size to the water service connection unless ductile iron MJ fittings are specified on the approved Plans.
- C. Copper Tubing:
 1. Comply with ASTM B88.
 2. Type: K, annealed.
 3. Fittings: Cast copper; ASME B16.18.
 4. Joints: Compression connection or flared connection.
- D. PVC Pipe:
 1. Comply with ASTM D1785 for Schedule 40 and Schedule 80, ASTM D2241 for SDR-26 (160-psig pressure rating), ASTM D2241 for SDR-41 (100-psig rating), and ASTM D2241 for SDR-21 (200-psig rating).
 2. Fittings: PVC; ASTM D2466.
 3. Joints: Solvent welded; ASTM D2855.

2.2 CORPORATION STOP ASSEMBLIES

- A. Manufacturers:
 1. A.Y. McDonald Mfg. Co.
 2. Hydro Instruments.
 3. Mueller Co.
 4. Substitutions: As specified in Section 016000 - Product Requirements.
 5. Furnish materials according to local and state standards.
- B. Corporation Stops:
 1. Comply with ASTM B62.
 2. Body: Brass or red brass alloy.
 3. Inlet End: Threaded for tapping according to AWWA C800.
 4. Outlet End: Suitable for service pipe specified.
- C. Service Saddles:
 1. Material: 85-5-5 brass alloy per ASTM B62, ASTM B584 and AWWA C800.
 2. Type: double strap, hinge-less design with two (2) fastening nuts on each side of the saddle body, incorporating an EPDM rubber gasket per ASTM D2000.
 3. Designed to hold pressures in excess of pipe working pressure.

2.3 CURB STOP ASSEMBLIES

A. Manufacturers:

1. A.Y. McDonald Mfg. Co.
2. Mueller Co.
3. Substitutions: As specified in Section 016000 - Product Requirements.
4. Furnish materials according to local and state standards.

B. Curb Stops:

1. Body: Brass or red brass alloy.
2. Comply with AWWA C800.
3. Valve Type: Ball.
4. Sealing: Positive pressure.

C. Curb Boxes and Covers:

1. Body: Cast iron.
2. Type: Extension.
3. Base: Minneapolis.
4. Lid:
 - a. Inscription: WATER.
 - b. Plug: Pentagonal.

2.4 BACKFLOW PREVENTERS

A. Manufacturers:

1. FEBCO; A WATTS Brand.
2. Flomatic Corporation.
3. Matco-Norca.
4. NIBCO INC.
5. WATTS.
6. Zurn Industries, LLC.
7. Substitutions: As specified in Section 016000 - Product Requirements.
8. Furnish materials according to local and state standards.

B. Reduced-Pressure Backflow Preventers:

1. Comply with ASSE 1013.
2. Materials:
 - a. Body: Bronze.
 - b. Internal Parts: Bronze.
 - c. Springs: Stainless steel.
3. Check Valves:
 - a. Quantity: Two, operating independently operating.
 - b. Spring-loaded.
 - c. Third Check Valve: Open under back pressure in case of diaphragm failure.

4. Differential Pressure Relief Valve:
 - a. Type: Diaphragm.
 - b. Location: Between check valves.
5. Gate Valves:
 - a. Type: Resilient seated.
 - b. Comply with AWWA C509.
 - c. Quantity: Two.
6. Accessories:
 - a. Non-threaded vent outlet.
 - b. Strainer.
 - c. Four resilient-seated ball valve test cocks.

C. Double-Check Valve Assemblies:

1. Comply with ASSE 1012.
2. Materials:
 - a. Body: Bronze.
 - b. Internal Parts: Corrosion resistant.
 - c. Springs: Stainless steel.
3. Check Valves:
 - a. Quantity: Two, operating independently.
 - b. Intermediate atmospheric vent.

2.5 METER BOXES

- A. In accordance with City of Raleigh requirements.

2.6 METER SETTING EQUIPMENT

- A. Manufacturers:
1. Mueller Co.
 2. Substitutions: As specified in Section 016000 - Product Requirements.
 3. Furnish materials according to local and state standards.
- B. Meter Setting:
1. Material:
 - a. Setter Tubing: Copper
 - b. Yoke: Iron or Copper
 - c. Valves: Brass
 2. Height: 12", unless otherwise noted.
 3. Inlet: Lockable angle inverted ball valve
 4. Key Valves:
 - a. Connection: Bronze pins and spring washers.
 5. Outlet: Expansion connection, dual check valve

6. End Connections: Flared copper tubing or compression type for plain end copper tubing.
7. Furnish test valves.

2.7 MATERIALS

- A. Bedding and Cover: As specified on the Plan Drawings and in accordance with authorities having jurisdiction.

2.8 ACCESSORIES

- A. Pipe Markers: In accordance with authorities having jurisdiction.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Section 017000 - Execution and Closeout Requirements.
- B. Verify that building service connections and municipal utility water main sizes, locations, and inverts are as indicated on Drawings.

3.2 PREPARATION

- A. Section 017000 - Execution and Closeout Requirements
- B. Cut pipe ends square, ream pipe and tube ends to full pipe diameter, and remove burrs.
- C. Remove scale and dirt from inside and outside of piping before assembly.
- D. Prepare pipe connections to equipment with flanges or unions.

3.3 INSTALLATION

- A. General:
 1. Water System Expansion:
 - a. For extensions of the existing water system, all buildable lots adjacent to the extension shall have a water service line provided unless otherwise directed. Additional service lines may be installed by the Contractor as directed and authorized by the Engineer.
 2. Rehabilitation of Existing Water Mains:
 - a. Where existing water mains are being rehabilitated, water service lines shall be constructed for each property that is occupied by a business or dwelling if it is currently served by the system being rehabilitated.
 - b. The Contractor shall be responsible to locate and connect all existing water service lines to the new main. In the event a service is missed during construction, the Contractor shall return to the site and perform all work necessary to reinstate the connection. The Contractor will be compensated in accordance with the original contract unit pricing; however, re-mobilization to the site will not be paid for.

- c. Service connections shall be made only after the new main has been tested and disinfected.
- d. Only enough new service tubing shall be required to connect the new water main to the existing service line on the street side of the meter. Meter yoke, meter, meter box, etc.; are all existing and shall remain in service. Reconnection of dwellings on the opposite side of the street from the new water mains will require replacement of the service tubing through bored holes to avoid damage to the existing pavement. The bored hole shall extend a minimum of 2 feet beyond the edge of pavement on each side of the road.

B. Corporation Stop Assemblies:

- 1. Make connection for each different kind of water main, using suitable materials, equipment, and methods as approved by Engineer.
- 2. Provide service clamps for mains constructed of materials other than cast iron or ductile iron.
- 3. Location:
 - a. Screw corporation stops directly into tapped and threaded iron main at 10- and 2-o'clock positions along main's circumference.
 - b. Locate and stagger corporation stops at least 12 inches apart longitudinally.
- 4. Plastic Pipe Mains:
 - a. Provide full support for service clamp for full circumference of pipe, with minimum 2-inch width of bearing area.
 - b. Exercise care against crushing or causing other damage to mains at time of tapping or installation of service clamp or corporation stop.
- 5. Use seals or other devices such that no leaks are present in mains at points of tapping.
- 6. Do not backfill and cover service connections until installation has been approved by Engineer.

C. Bedding:

- 1. Excavate pipe trench and backfill in accordance with the Plan Drawings and these specifications.
- 2. Placement:
 - a. Place bedding material as indicated on Drawings.
 - b. Level fill materials in one continuous layer not exceeding 8 inches of compacted depth.
 - c. Compact to 95 percent maximum density.
- 3. Backfill around sides and to top of pipe with cover fill, tamp in place, and compact to 95 percent maximum density.
- 4. Maintain optimum moisture content of fill material to attain required compaction density.

D. Pipe and Fittings:

- 1. Maintain separation of water main from sewer piping according to state standards code.
- 2. Group piping with other Site piping Work whenever practical.
- 3. Install pipe to allow for expansion and contraction without stressing pipe or joints.
- 4. Install access fittings to permit disinfection of water system.

5. Thrust Restraints: Form and place concrete for thrust restraints at each elbow or change of direction of pipe.
6. Establish elevations of buried piping with not less than three feet of cover.
7. Pipe Markers: As specified in Section 330597 - Identification and Signage for Utilities.
8. Backfill trench as shown on the Plan Drawings and in accordance with authorities having jurisdiction.

E. Curb Stop Assemblies:

1. Set curb stops on compacted soil.
2. Boxes:
 - a. Center and plumb curb boxes over curb stops.
 - b. Set box cover flush with finished grade.

F. Water Meters: Install positive displacement meters according to AWWA M6, with isolating valves on inlet and outlet as indicated on Drawings.

G. Backflow Preventers:

1. Install backflow preventers where indicated on Drawings and according to manufacturer instructions.
2. Testing and Installation Requirements: Comply with local water company requirements and plumbing codes.

H. Service Connections:

1. Install water service according to utility company requirements and as indicated on Drawings.
2. Install water service to within 5 feet of building unless otherwise indicated.

I. Disinfection of Water Piping System: Flush and disinfect system in accordance with authorities having jurisdiction.

J. Installation Standards: Install Work according to municipal and state standards.

3.4 TOLERANCES

- A. Install pipe to indicated elevation to within tolerance of 5/8-inch.

3.5 FIELD QUALITY CONTROL

- A. Section 014000 - Quality Requirements: Requirements for inspecting and testing.
- B. Section 017000 - Execution and Closeout Requirements: Requirements for testing, adjusting, and balancing.
- C. Testing: In accordance with authorities having jurisdiction.
- D. Perform pressure test on water distribution system according to municipal and state standards.
- E. Compaction Testing for Bedding: In accordance with authorities having jurisdiction.

- F. If tests indicate Work does not meet specified requirements, remove Work, replace, and retest.
- G. Frequency of Compaction Tests: In accordance with local and state requirements.

END OF SECTION 331417

SECTION 331419 - VALVES AND HYDRANTS FOR WATER UTILITY SERVICE**PART 1 - GENERAL****1.1 SUMMARY****A. Section Includes:**

1. Valves.
2. Valve boxes.
3. Fire hydrants.

1.2 REFERENCE STANDARDS**A. American Society of Mechanical Engineers:**

1. ASME B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.

B. American Water Works Association:

1. AWWA C110 - Ductile-Iron and Gray-Iron Fittings.
2. AWWA C500 - Metal-Seated Gate Valves for Water Supply Service.
3. AWWA C502 - Dry-Barrel Fire Hydrants.
4. AWWA C504 - Rubber Seated Butterfly Valves, 3 In. through 72 In.
5. AWWA C507 - Ball Valves, 6 in. through 60 in.
6. AWWA C508 - Swing-Check Valves for Waterworks Service, 2-In. through 24-In. NPS.
7. AWWA C509 - Resilient-Seated Gate Valves for Water Supply Service.
8. AWWA C512 - Air-Release, Air/Vacuum, and Combination Air Valves for Waterworks Service.
9. AWWA C515 - Reduced-Wall, Resilient-Seated Gate Valves for Water Supply Service.
10. AWWA C550 - Protective Interior Coatings for Valves and Hydrants.

C. ASTM International:

1. ASTM A48 - Standard Specification for Gray Iron Castings.
2. ASTM A126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
3. ASTM A536 - Standard Specification for Ductile Iron Castings.
4. ASTM D429 - Standard Test Methods for Rubber Property-Adhesion to Rigid Substrates.
5. ASTM D1784 - Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
6. ASTM D2000 - Standard Classification System for Rubber Products in Automotive Applications.

D. Manufacturers Standardization Society of the Valve and Fittings Industry:

1. MSS SP-60 - Connecting Flange Joints between Tapping Sleeves and Tapping Valves.
2. MSS SP-110 - Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends.

E. National Fire Protection Association:

1. NFPA 291 - Recommended Practice for Fire Flow Testing and Marking of Hydrants.

F. NSF International:

1. NSF 61 - Drinking Water System Components - Health Effects.

2. NSF 372 - Drinking Water System Components - Lead Content.

1.3 COORDINATION

- A. Section 013000 - Administrative Requirements: Requirements for coordination.
- B. Coordinate Work of this Section with installation of water mains.

1.4 SUBMITTALS

- A. Section 013300 - Submittal Procedures: Requirements for submittals.
- B. Product Data: Submit manufacturer information regarding component materials, fittings, assembly and parts diagram, and accessories.
- C. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.
- D. Manufacturer Instructions: Submit detailed instructions on installation requirements, including storage and handling procedures.
- E. Source Quality-Control Submittals: Indicate results of factory tests and inspections.
- F. Field Quality-Control Submittals: Indicate results of CONTRACTOR-furnished tests and inspections.

1.5 CLOSEOUT SUBMITTALS

- A. Section 017000 - Execution and Closeout Requirements: Requirements for submittals.
- B. Project Record Documents: Record actual locations of valves and hydrants.

1.6 QUALITY ASSURANCE

- A. Materials in Contact with Potable Water: Certified according to NSF 61 and NSF 372.
- B. Cast manufacturer's name, pressure rating, and year of fabrication into valve body.
- C. Perform Work according to authorities having jurisdiction.

1.7 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing products specified in this Section with minimum three years' documented experience.
- B. Installer: Company specializing in performing Work of this Section with minimum three years' documented experience.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Section 016000 - Product Requirements: Requirements for transporting, handling, storing, and protecting products.
- B. Delivery:
 - 1. Seal valve and hydrant ends to prevent entry of foreign matter.
 - 2. Inspection: Accept materials on Site in manufacturer's original packaging and inspect for damage.
- C. Store materials according to manufacturer instructions.
- D. Protection:
 - 1. Protect materials from moisture and dust by storing in clean, dry location remote from construction operations areas.
 - 2. Provide additional protection according to manufacturer instructions.

PART 2 - PRODUCTS

2.1 VALVES

- A. Unless otherwise noted, valves shall have the following performance and design criteria:
 - 1. Pressure Rating:
 - a. 12-inch Diameter and Smaller: 200 psig.
 - b. 14-inch Diameter and Larger: 150 psig.
 - 2. Underground (Buried) Installations:
 - a. Mechanical joint connections.
 - b. Non-rising stem type.
 - c. 2-inch square operating nut.
 - 3. Above Ground Installations:
 - a. Flanged ends with Class 125 flanges unless otherwise noted.
 - b. Rising stems, unless otherwise noted, with outside stem and yoke and 18-inch diameter minimum hand wheel.
 - c. All valves shall be operated by handwheel.
 - 4. Valves shall have a clear waterway equal to the full nominal diameter of the pipe.
 - 5. Each valve shall have the initials or name of the maker, pressure rating and year of manufacture cast on the body.
 - 6. Valves shall have an arrow cast in the operating nut indicating the direction of opening.
 - 7. Coatings:
 - a. Comply with AWWA C550.
 - b. Application: Interior and exterior.
 - 8. Operation: Counterclockwise opening.
- B. Resilient-Wedge Gate Valves:
 - 1. Description:
 - a. Gate valves 2 inches through 24 inches in diameter size shall be of the resilient seated wedge type in accordance with AWWA C509 or C515. All valves shall be from one manufacturer and parts interchangeable.
 - b. Materials:
 - 1) Body, bonnet, and gate: Cast iron or ductile iron.
 - 2) Stem: Cast bronze with integral collars.

- c. Coating:
 - 1) The valve body and bonnet shall be coated on both the interior and exterior surfaces with an NSF 61 approved fusion bonded epoxy paint conforming to AWWA C550.
 - 2) The gate shall be fully coated in accordance with ASTM D2000. Coating adhesion shall be in accordance with ASTM D429.
 - d. Stem:
 - 1) Non-rising stems shall have two O-rings located above thrust collar and one O-ring below. The non-rising stems on 4"-12" valves shall also have two low torque thrust bearings located above and below the stem collar to reduce friction during operation.
 - e. Operation:
 - 1) Where called for in Plans, valves larger than 12 inches in diameter shall be designed for horizontal installation with beveled gear boxes with reduction gears to reduce the number of turns required to operate valve.
- C. Double-Disc Gate Valves:
- 1. Description:
 - a. Gate valves larger than 24 inches in diameter shall be of the double disc parallel seat type. All valves shall be from one manufacturer and parts interchangeable. Valves shall have a working pressure of 150 PSI.
 - b. Comply with AWWA C500.
 - c. Materials:
 - 1) Body, bonnet, and gate: Ductile iron conforming to ASTM A536.
 - 2) Gates: High strength cast iron.
 - 3) Stem: Cast bronze
 - 4) Trim, rollers, tracks, and scrapers: Bronze.
 - d. Coating: The valve body and bonnet shall be coated on both the interior and exterior surfaces with an NSF 61 approved fusion bonded epoxy paint conforming to AWWA C550.
 - e. Valves shall use bottom wedging type design with a two-part floating wedge contact. The wedge and hook shall be separate castings and not a single piece.
 - f. The stuffing box shall use "O"-ring seal type with two rings located above the thrust collar. The rings shall be replaceable with the valve fully open and under pressure. Flat gaskets and blind bolts are not allowed.
 - g. Operation:
 - 1) Horizontal installation with beveled gear boxes with reduction gears to reduce the number of turns required to operate valve.
- D. Butterfly Valves:
- 1. Description:
 - a. Butterfly valves shall be of the tight-closing type with zero leakage at rated pressures with flow in either direction and shall be satisfactory for frequent operation and for applications involving valve operation after long periods of inactivity.
 - b. Butterfly valves shall be Class 150B in accordance with AWWA C504.
 - c. Materials:
 - 1) Body: Cast iron (flanged - ASTM A126 Class B, mechanical joint – ASTM A48 Class 40) or ductile iron (ASTM A536 Grade 65 45 12)
 - 2) Seat ring: Stainless-steel that is mechanically retained without use of clamping devices, adjusting segments, or other hardware being in the waterway.
 - 3) Valve Disc: ductile iron without any external vanes, ribs, etc., to obstruct flow or alloy cast iron.
 - 4) Shaft: 18-8 Type 304 or Type 316 stainless-steel.
 - 5) Taper keys: 416 stainless-steel.

- d. Coatings:
 - 1) Valve body shall be primed with manufacturer's standard primer.
 - 2) Rubber seats shall be securely fastened to the valve body. No metal-to-metal seating surfaces shall be permitted. Valves shall have seats that are simultaneously molded in, vulcanized and bonded to the body. Seat bond must withstand 75 lbs. pull under test procedure ASTM D429, Method B.
 - e. Discs and Resilient Seat:
 - 1) Seat shall be located on edge of disc, offset from the shaft, and seal against mating stainless steel body seat with 360-degree uninterrupted contact.
 - 2) Valve discs shall rotate 90 degrees from the fully open position to the tight shut position.
 - 3) The resilient seal shall be locked to the disc by three separate means of retention, and be field-adjustable, if necessary, with no tools other than a standard socket wrench.
 - 4) Replacement of seat in field shall be possible without valve disassembly.
 - f. Shaft:
 - 1) The disc shall be connected to the offset shaft by locked taper wedge keys and stainless-steel retaining nuts on the back side of the disc.
 - 2) Shaft shall be stub type for valves 30 inches and larger in diameter; one piece for valves 24 inches in diameter and smaller.
 - 3) The valve shall be equipped with adjustable thruster for centering the disc on valves 30 inches and larger in diameter, if required.
 - 4) Two trunnions for shaft bearings shall be integral with each valve body.
 - 5) Shaft shall have nylon sleeve or woven Teflon fibreglassed backed sleeve for bearing surfaces. Bearings shall be corrosion resistant and self-lubricating.
 - 6) Bearing load shall not exceed 1/5 of the compressive strength of the bearing or shaft material.
 - 7) Shafts shall be turned, ground and polished.
 - g. Operation:
 - 1) Manual operators shall be of the traveling nut, self-locking type and shall be designed to hold the valve in any intermediate position between fully open and fully closed without creeping or fluttering.
 - 2) Operators shall be equipped with mechanical stop-limiting devices to prevent over-travel of the disc in the open and closed positions.
 - 3) Operators shall be fully enclosed and designed to produce the specified torque with a maximum pull of 80 lb. on the operator or handwheel.
 - 4) Operator components shall withstand an input of 150 Ft.-Lbs. at extreme operator position without damage.
- E. Valves 1-1/2 Inches and Smaller
- 1. Description:
 - a. Unless otherwise noted, valves shall be full port ball valves with adjustable packing suitable for underground installation.
 - b. Comply with MSS-SP-110.
 - c. Body: Forged brass
 - d. End Connections: Threaded ends conforming to NPT standards.
 - e. Operation: Quarter-turn.
- F. PVC Ball Valves:
- 1. Description:
 - a. PVC ball valves 1/2-inch to 2-inch shall be true union design and 3-inch valves shall be a single union design.
 - b. Materials:
 - 1) Body: from Type 1, Grade 1, Polyvinyl Chloride as outlined in ASTM D1784.
 - 2) Ball seals: Teflon

- 3) Stem and body seals: Viton
 - c. The valves shall carry a pressure rating of 150 psi at 73 degrees F.
- G. Air Release and Combination Air/Vacuum Valves:
 - 1. Description:
 - a. Air release and combination air/vacuum valves shall be rated for a working pressure of 150 PSI minimum and hydrostatic test pressure of 300 PSI.
 - b. Combination air valves shall combine the operation of both an air/vacuum and air release valve.
 - c. Comply with AWWA C512.
 - d. Materials:
 - 1) Body: Cast iron or Type 304 or 316 stainless steel, or as specified.
 - e. Inlets:
 - 1) The valve shall have a minimum two (2) inch NPT inlet.
 - 2) Combination air valves sized from 2 inches to 4 inches shall be provided with NPT inlets and outlets unless otherwise submitted for approval with flanged connections.
- H. Swing Check Valves:
 - 1. Description
 - a. Check valves shall be in accordance with AWWA C508.
 - 2. Materials:
 - a. Body: high strength cast iron conforming to ASTM A126 Class B with integral flanges, faced and drilled per ANSI B16.1 Class 125 and be suitable for horizontal or vertical installation.
 - b. Body seat ring: Stainless steel and shall be mechanically retained by means of roll pins or stainless-steel cap screws. The body seat ring shall be replaceable.
 - c. Disc: Cast iron per ASTM A126 Class B, bronze, or alloy cast iron with bronze or stainless-steel disc rings.
 - d. Disc arm: Ductile iron or steel.
 - e. Shaft: Austenitic stainless-steel.
 - 3. Disc:
 - a. The valve disc shall be attached to the disc arm by means of a single center pin permitting 360-degree articulation.
 - b. The disc shall present a convex surface to the direction of flow to compensate for oscillation.
 - c. Disc seats shall be replaceable.
 - 4. Shaft:
 - a. The shaft shall rotate freely without the need for external lubrication.
 - b. The shaft shall be sealed where it passes through the body by means of a stuffing box and adjustable packing.
 - c. Simple O-ring shaft seals are not acceptable. Hinge shafts shall be constructed of 316 stainless steel.
 - d. Pivot pins and bushings: bronze or stainless steel.
 - 5. The valve body shall be the full waterway type, designed to provide a net flow area not less than the nominal inlet pipe size when swung open no more than 25 degrees.
 - 6. Unless otherwise noted, the valve shall be supplied with an outside lever and adjustable counterweight to initiate valve closure.
 - 7. Air Cushioned Swing Check Valve:
 - a. Final closure shall be dampened by means of a single, side-mounted bronze air-cushion assembly directly mounted to the valve body on machined pads. The amount of cushioning shall be easily adjustable without the need for pre-charged air chambers. Commercial air cylinders, which pivot and/or are attached with fabricated brackets, are not acceptable.
- I. Ball Check Valves:

1. Description:
 - a. Material:
 - 1) ASTM A536 ductile iron with sinking type ball made of a hollow metal core with vulcanized nitrile rubber covering, or;
 - 2) ASTM D1784 PVC with sinking type ball made of nitrile or Teflon.
 - b. The valves shall insure a positive seal to prevent reverse flow even with extremely low back pressure.
 - c. The valves shall be designed for horizontal or vertical installation and have a removable cover to permit inspection.

2.2 TAPPING SLEEVES AND VALVES

A. Tapping Sleeves:

1. Description:
 - a. Material: Ductile iron meeting ASTM A536 Grade 65-45-12.
 - b. Type: Dual compression.
 - c. Outlet Flange
 - 1) Comply with ASME B16.1, Class 125, and MSS SP-60.
 - 2) Outlet flange seals shall be of the O-Ring type of either round, oval, or rectangular cross-sectional shape
 - d. Bolts
 - 1) Body: High strength cast iron bolts.
 - 2) Glands: Steel bolts fastened to the bell opening of the sleeves.
 - e. Gasket: full circumferential type providing a 360° seal around existing pipe.
 - f. Bituminous Coating: Comply with AWWA C110.

B. Tapping Valves:

1. Description:
 - a. Valves will be identical to resilient wedge gate valves elsewhere specified with inlet and outlet ends adaptable to the tapping machine and to provide mechanical joint connections to discharge pipes

2.3 FIRE HYDRANTS

A. Manufacturers:

1. The fire hydrants shall be manufactured by one of the following or approved equal.
 - a. Mueller
 - b. American Darling
 - c. Kennedy or
 - d. Clow.

B. Dry-Barrel, Breakaway Type:

1. Comply with AWWA C502.
2. Design:
 - a. Hydrants shall be of the traffic or safety model type incorporating a break away flange arrangement which will permit the upper section of the hydrant barrel to separate from the lower section upon impact and the hydrant valve will remain closed and reasonably tight.
3. Rating: Designed for a minimum working pressure of 150 psi and a hydrostatic test pressure of 300 psi with the valve in both the open and closed positions.
4. Burial Depth:

- a. All hydrants shall be furnished with barrel and stem extensions as required to provide a nominal minimum cover of approximately three feet or greater if so required by field conditions.
 5. Main Valve:
 - a. Size: 5-1/4 inches, unless otherwise specified.
 - b. Type: Compression type, closing with line pressure and capable of withstanding 250 PSI working pressures and 500 PSI hydrostatic test pressures, unless otherwise specified.
 - c. The valve seat ring shall thread into a bronze sub-seat, and all gaskets sealing the seat ring shall be a bronze-to-bronze surface.
 6. Drain Valve: All bronze and allowing complete drainage of all residual water in the hydrant barrel.
 7. Opening Nut: Pentagonal, 1-1/2 inches from the point to the flat, counterclockwise opening.
 8. Stem and Seals:
 - a. Hydrants shall be of the "dry top" type with the upper rod threads completely enclosed in a sealed grease or oil chamber to lubricate the entire length of the threaded part of the valve stem each time the hydrant is operated.
 - b. All-weather grease shall be used to provide permanent lubrication. A thermoplastic thrust washer shall be used to reduce friction in the thrust collar while opening the hydrant.
 - c. Two (2) "O"-ring seals between the revolving nut and bronze-sheathed upper section of the valve rod shall be utilized to ensure that threads on the valve stem do not come into contact with water at any time.
 - d. The top of the rod shall also be fitted with a travel stop nut to limit downward travel of the rod.
 9. End Connections: 6-inch Mechanical joint.
 - a. Joint restraint, if specified, shall be accomplished for mechanical joint by use of mechanical joint gripper glands.
 10. Bolts and Nuts: Stainless steel.
 11. Interior Coating: Comply with AWWA C550.
- C. Hose Connections:
1. One 4-1/2-inch pumper nozzle.
 2. Two (2) 2-1/2-inch hose nozzles.
 3. All connections shall be bronze with National Standard Threads, unless otherwise specified by authority having jurisdiction.
 4. Cast iron nozzle caps attached by separate steel chains.
 5. Nozzles shall be reverse threaded into the fire hydrant barrel.
- D. Finishes:
1. All hydrants shall be painted the manufacturer's standard red unless otherwise specified.
 2. Color: Comply with requirements of utility company or fire department.
- 2.4 YARD HYDRANTS
- A. Casing: 1-1/4"-inch galvanized steel pipe freeze-less.
- B. Inlet: 1" NPT.
- C. Nozzles:
1. One (1) standard removable 3/4-inch hose nozzle.
 2. Provide and install 3 cubic feet of crushed stone at freeze drain.

2.5 FREEZE-PROOF HOSE BIBS

- A. Manufacturers:
 - 1. The hose bibs shall be manufactured by Nibco (No. 74VB) or approved equal.
- B. All hose bibs shall be freeze-proof.

2.6 VALVE BOXES

- A. Description: Valve boxes shall be of the close-grained gray cast iron and adjustable. The word "WATER" shall be cast in the lid. Valve boxes shall be coated with a protective bituminous coat before being shipped from the factory. Valve box weight shall not bear upon the valve bonnet.
- B. Precast Concrete Valve Box Protector Ring:
 - 1. Each cast iron valve box located outside of paved areas shall be installed with a 24" diameter, precast reinforced concrete protector ring.
 - 2. Each cast iron valve box located in a paved area shall have a cast in place 24" x 24" x 7-1/2" concrete encasement installed 2" below grade with the top 2-1/2" being asphalt.

PART 3 - EXECUTION**3.1 EXAMINATION**

- A. Section 017000 - Execution and Closeout Requirements: Requirements for installation examination.
- B. Determine exact location and size of valves from Drawings.
- C. Identify required lines, levels, contours, and datum locations.
- D. Verify that elevations of existing facilities prior to excavation and installation of valves and hydrants are as indicated on Drawings.

3.2 PREPARATION

- A. Section 017000 - Execution and Closeout Requirements: Requirements for installation preparation.
- B. Locate, identify, and protect from damage utilities to remain.
- C. Do not interrupt existing utilities without permission and without making arrangements to provide temporary utility services.
 - 1. Notify ENGINEER not less than two days in advance of proposed utility interruption.
 - 2. Do not proceed without written permission from ENGINEER.

3.3 INSTALLATION

- A. General:

1. CONTRACTOR shall provide all materials, labor, tools, equipment and incidentals required for the excavation, installation, backfilling and testing of valves and/or hydrants and associated appurtenances.
 2. All valves and hydrants shall be installed in accordance with the manufacturer's instructions.
 3. Valves, hydrants and accessories shall be carefully lowered into the trench with suitable equipment in a manner that will prevent damage.
 4. Perform trench excavation, backfilling, and compaction as specified.
 5. Disinfection of Water Piping System: Flush and disinfect valves and hydrants with water mains as specified.
 6. Install valves and hydrants in conjunction with pipe laying.
- B. Valve Installation:
1. Before setting each valve, the CONTRACTOR shall make sure the interior is clean and test opening and closing.
 2. Valves shall be set with stems plumb, unless horizontal installation is called for on the plans, and at the exact locations shown.
 3. Provide buried valves with valve boxes installed flush with finished grade.
 4. Air Release and Combination Air/Vacuum Valves:
 - a. All air release and combination air/vacuum valve assemblies shall be:
 - 1) Installed at locations shown and in accordance with specifications and details provided on the Plans.
 - 2) Installed in standard eccentric manhole.
 - 3) Provided with a saddle tap of the same size as the combination air valve assembly and isolated with a gate valve of the same size. The isolation gate valve shall be provided with NPT threads and connected with brass or bronze piping. Brass or bronze ball valves may be used in lieu of gate valves for installations 2 inches or smaller. The isolation valve shall be rated for 200 psi service or greater.
 5. Tapping Sleeves and Valves:
 - a. As indicated on Plans and according to manufacturer instructions. All sleeves are to include the end joint accessories and split glands necessary to assemble sleeve to pipe. Concrete thrust blocks shall be installed as specified prior to backfilling.
- C. Valve Box Installation:
1. A valve box shall be installed over each underground valve. All boxes shall be installed in accordance with the manufacturer's instructions and set plumb and centered on the operating nut. Top of the valve box shall be flush with finished grade and with a precast concrete "donut" unless located within a hardened surface such as roadway or concrete slab.
- D. Fire Hydrant Installation:
1. Fire hydrants shall be located as shown on Plans.
 2. Each hydrant shall be connected to the main with a 6-inch diameter branch line, which shall include a 6-inch gate valve. The branch line shall have at least as much cover as the distribution main.
 3. Hydrants shall be rodded to the 6-inch branch tee.
 4. Orientation:
 - a. Set valves and hydrants plumb.
 - b. Set fire hydrants with pumper nozzle facing roadway.
 - c. Set fire hydrants with centerline of pumper nozzle 18 inches above finished grade and with safety flange above grade but not more than 2 inches above grade.
 5. Provide thrust blocking and not less than eight (8) cubic feet of drainage gravel while installing fire hydrants; do not block drain hole. Place a cap block beneath the fire hydrant foot for a solid bottom.
 6. After main-line pressure testing, flush fire hydrants and check for proper drainage.

3.4 FIELD QUALITY CONTROL

- A. Section 014000 - Quality Requirements: Requirements for inspecting and testing.
- B. Section 017000 - Execution and Closeout Requirements: Requirements for testing, adjusting, and balancing.
- C. Testing: Pressure test valves and hydrants with water mains as specified and in accordance with authorities having jurisdiction.

END OF SECTION 331419

SECTION 333111 - PUBLIC SANITARY SEWERAGE GRAVITY PIPING**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes:
 - 1. Sanitary sewerage piping.
 - 2. Connection to existing manholes.
 - 3. Wye branches and tees.
 - 4. Sanitary laterals.
 - 5. Pile support systems.
 - 6. Bedding and cover materials.

1.2 DEFINITIONS

- A. ABS: Acrylonitrile butadiene styrene.
- B. Bedding: Fill placed under, beside, and directly over pipe, prior to subsequent backfill operations.
- C. EPDM: Ethylene-propylene-diene terpolymer.

1.3 REFERENCE STANDARDS

- A. American Water Works Association:
 - 1. AWWA C105 - Polyethylene Encasement for Ductile-Iron Pipe Systems.
 - 2. AWWA C150 - Thickness Design of Ductile-Iron Pipe.
 - 3. AWWA C151 - Ductile-Iron Pipe, Centrifugally Cast.
 - 4. AWWA C600 - Installation of Ductile-Iron Mains and Their Appurtenances.
- B. ASTM International:
 - 1. ASTM A746 - Standard Specification for Ductile Iron Gravity Sewer Pipe
 - 2. ASTM C923 - Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes, and Laterals.
 - 3. ASTM D1785 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
 - 4. ASTM D2321 - Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications.
 - 5. ASTM D3034 - Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
 - 6. ASTM F477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
 - 7. ASTM F1668 - Standard Guide for Construction Procedures for Buried Plastic Pipe

1.4 COORDINATION

- A. Section 013000 - Administrative Requirements: Requirements for coordination.

- B. Coordinate Work of this Section with appropriate utilities department.
- C. Do not interrupt service to facilities occupied by Owner or others unless approved by the Engineer and Owner no fewer than 72 hours in advance of proposed interruption and after arranging to provide temporary sewer service.

1.5 SUBMITTALS

- A. Section 013300 - Submittal Procedures: Requirements for submittals.
- B. Product Data: Submit manufacturer information indicating proposed materials, accessories, details, and construction information.
- C. Installation manuals shall be furnished to the Engineer for his review and approval prior to installation of any materials. The Engineer may augment any manufacturer's installation recommendations if, in his opinion, it will best serve the interest of the Owner.
- D. Shop Drawings:
 - 1. Drawings and descriptive data on manholes (including wall thicknesses, vertical dimensions, and deflection angles), concrete used in manufacture of manholes and precast inverts, rubber gaskets, joint sealant, flexible manhole sleeves and joints, frames and covers, inverts, and manhole steps shall be submitted to the Engineer for review prior to their manufacture.
 - 2. All sizes and types of pipe.
 - 3. All pipe fittings and appurtenances.
 - 4. All transition couplings.
- E. Field Quality-Control Submittals: Indicate results of Contractor-furnished tests and inspections.
- F. Preconstruction Photographs and/or Video: Submit digital files of photographs and/or video of Work areas and material storage areas prior to construction, as specified in Section 013300 – Submittal Procedures.
- G. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.
- H. Manufacturer Instructions:
 - 1. Indicate special procedures required to install specified products.
 - 2. Submit detailed description of procedures for connecting new sewer to existing sewer line and directional drilling installation.
 - 3. Source Quality-Control Submittals: Indicate results of factory tests and inspections.

1.6 CLOSEOUT SUBMITTALS

- A. Section 017000 - Execution and Closeout Requirements: Requirements for submittals.
- B. Project Record Documents: Record invert elevations and actual locations of pipe runs, connections, material changes, manholes service lines, and cleanouts.
- C. Identify and describe unexpected variations to subsoil conditions or discovery of uncharted utilities.

1.7 QUALITY ASSURANCE

- A. Perform Work according to 15A NCAC 02T and the following requirements:
 - 1. Comply with all requirements of utility OWNER.
 - 2. Comply with all standards of authorities having jurisdiction for public sanitary sewerage, including materials, installation, and testing.
- B. All piping materials shall bear label, stamp, or other markings of specified testing agency.

1.8 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing products specified in this Section with minimum three years' documented experience.
- B. Installer: Company specializing in performing Work of this Section with minimum three years' documented experience.
- C. The design, installation, and operation of any temporary pumping system, when required to maintain sewer flows in the existing system, shall be the Contractor's responsibility. Demonstrate experience in the design and operation of temporary bypass pumping systems or employ the services of a vendor who can demonstrate this experience. The Contractor or vendor shall provide at least five (5) references of projects of a similar size and complexity as this project performed within the past three (3) years. The bypass system shall meet the requirements of all codes and regulatory agencies having jurisdiction and not interrupt existing wastewater service nor cause road closures.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Section 016000 - Product Requirements: Requirements for transporting, handling, storing, and protecting products.
- B. Inspection: Accept materials on Site in manufacturer's original packaging and inspect for damage.
- C. Transport: Unload pipe and appurtenances to avoid deformation or other injury thereto. Pipe shall not be placed within pipe of a larger size and shall not be rolled or dragged over gravel or rock during handling. If any defective material is discovered after installation, remove, and replace with sound pipe or repair in an approved manner at no additional cost to the Owner.
- D. Storage:
 - 1. Store materials according to manufacturer instructions.
 - 2. Store valves in shipping containers with labeling in place.
 - 3. Block individual and stockpiled pipe lengths to prevent moving.
 - 4. Do not place pipe or pipe materials on private property or in areas obstructing pedestrian or vehicle traffic.
 - 5. Store plastic materials out of sunlight.
 - 6. Store all pipe and appurtenances on sills above storm drainage level and deliver for laying after the trench is excavated.
- E. Protection:

1. Protect materials from moisture and dust by storing in clean, dry location remote from construction operations areas.
2. Plastic materials shall be supported to prevent sagging and bending.
3. Plastic materials shall be covered with tarps.
4. Provide additional protection according to manufacturer instructions.
5. When any material is damaged during transporting, unloading, handling, or storing, the undamaged portions may be used as needed, or, if damaged sufficiently, the Engineer will reject the material as being unfit for installation. The Engineer will reject any ductile iron pipe with a damaged cement mortar lining.

1.10 EXISTING CONDITIONS

A. Field Measurements:

1. Verify field measurements prior to fabrication.
2. Indicate field measurements on Shop Drawings.

B. Existing Service:

1. Interruption of Existing Sanitary Sewerage Service: The interruption of sewer flows within the collection system or service to any occupied structure or facility will not be permitted unless specifically approved by the utility Owner. Maintain sewer flows at all times.
2. When by-pass pumping of sewer flows is necessary, submit a by-pass pumping work plan to the Engineer and utility Owner as specified.

PART 2 - PRODUCTS

2.1 GENERAL

- A. All materials shall be first quality with smooth interior and exterior surfaces, free from cracks, blisters, honeycombs, and other imperfections, and true to theoretical shapes and forms throughout.
- B. As particular specifications are cited, the designation shall be construed to refer to the latest revision under the same specification number, or to superseding specifications under a new number except provisions in revised specifications which are clearly inapplicable.

2.2 SANITARY SEWERAGE PIPING

A. Gaskets

1. Gasket material shall be Styrene Butadiene Copolymer (SBR) unless otherwise noted.

B. Ductile Iron Pipe:

1. All ductile iron pipe shall conform to ASTM A746 and be Pressure Class 350 unless otherwise specified. Class numbers or pressure rating shall be clearly marked on the pipe and fittings at the factory.
2. Ductile iron pipe shall be of the size indicated on the Drawings and shall be designed in accordance with AWWA C150 and manufactured in accordance with AWWA C151.
3. Bituminous Outside Coating
 - a. All ductile iron pipe shall have an outside pipe coating of an asphaltic material a minimum of 1 mil thickness in accordance with AWWA C151. The final coat shall be continuous and smooth being neither brittle when subjected to low

temperatures nor sticky when exposed to hot sun. The coating shall adhere to the pipe at all temperatures.

4. Interior Lining
 - a. Unless otherwise specified, line the interior of all ductile iron pipe and fittings with a ceramic epoxy coating consisting of two-part component, amine cured novalac epoxy containing a minimum of 20% by volume ceramic pigmentation.
5. Joints:
 - a. Unless otherwise shown on the Drawings, pipe joints shall be push joint type.
6. Long Span Pipe:
 - a. "Long span" type ductile iron pipe shall be used for unsupported spans greater than 20'-0". "Long span" ductile iron pipe and associated pipe joints shall be designed by the pipe manufacturer specifically for elevated crossings with unsupported spans shown on the drawings. Submit shop drawings from the pipe manufacturer for the long span pipe. Shop drawings shall include material specifications for the pipe and joints and shall specify locations of joints with respect to the pier locations shown on the drawings. Long span ductile iron pipe shall be as manufactured by American, U.S. Pipe, or equal.

C. PVC

1. All PVC pipe shall conform to Type PSM SDR-35PVC unless otherwise specified. Class and pressure rating shall be clearly marked on the pipe at the factory.
2. PVC pipe shall be of the size indicated on the Drawings and shall be designed in accordance with ASTM D3034.
3. Pipe shall be supplied in 20-foot lengths.
4. Joints:
 - a. Unless otherwise shown on the Drawings, pipe joints shall be bell-and-spigot style, with rubber-ring-sealed gasketed compression type joints.
 - b. Joints and gaskets to comply with ASTM F477 and ASTM D3212.
5. Fittings: PVC or as shown on the Drawings.

D. PVC Pressure Pipe for Gravity Sewer Applications Conforming to Water Main Standards:

1. PVC pressure pipe for gravity sewer applications conforming to water main standards shall be used where called for on the Drawings.
2. Material: Type I, Grade I Polyvinyl Chloride (PVC) compound with a Cell Classification of 12454 per ASTM D1784.
3. Comply with ASTM D2241.
4. Minimum SDR 26, Pressure Rated 160.
5. Pipe shall be green in color signifying its use in a sewer application.
6. Joints
 - a. Pipe shall have an integral elastomeric-gasket bell end.
 - b. Joints and gaskets to comply with ASTM F477 and ASTM D3139.

2.3 WYE BRANCHES AND SADDLES

A. Wye Branches

1. Material: Wyes shall be of the same material and strength as the sewer mains on which they are installed.
2. PVC wyes shall conform to ASTM D3034 and DIP wyes to ASTM A536.

B. Saddles

1. Use saddle wye or tee with stainless steel clamps for taps into existing piping.
2. Saddle type fittings shall not be used on new construction.
3. Material
 - a. Saddles shall be of the same material and strength as the sewer mains on which they are installed.

- b. Straps and hardware shall be 304 stainless steel.
- 4. Saddles on PVC pipe shall comply with ASTM D3034.
- 5. Saddles on PVC pipe shall comply with ASTM A536.
- 6. Lay out holes with template and cut holes with mechanical cutter.

2.4 SERVICE LATERALS

- A. Unless otherwise specified in the Plans and/or Specifications, service laterals shall be constructed of 4-inch diameter Schedule 40 PVC pipe or Class 350 psi ductile iron pipe, including the cleanout stack.
- B. PVC pipe shall comply with ASTM D1785.

2.5 FLEXIBLE COUPLINGS

- A. The use of flexible couplings will not be allowed on a new gravity system unless specifically called for on the Drawings.
- B. In general, during the rehabilitation of existing sewer lines, the use of appropriate transition couplings shall be permitted as approved by the ENGINEER. All changes in pipe size within the gravity sewer collection system shall require the installation of a manhole as specified elsewhere.
- C. Couplings shall comply with the following:
 - 1. Material: Shielded rubber sleeve with a stainless-steel shear ring and clamps
 - 2. Sleeve shall comply with ASTM C425 and ASTM C1173. Shear ring shall comply with ASTM A240.
 - 3. Accessories: Clamps shall be included with nut and bolt or worm drive take-up fasteners. "O" ring-type seals shall be provided under each sealing clamp to prevent slippage and provide a positive seal.
 - 4. The gap between the pipe sections being jointed shall not exceed 0.25 inches.
- D. Only electro-fusion couplings shall be used when connecting HDPE pipe.

2.6 FLEXIBLE PIPE BOOTS FOR MANHOLE PIPE ENTRANCES

- A. Description:
 - 1. Material: Ethylene-propylene-diene terpolymer (EPDM).
 - 2. Comply with ASTM C923.
 - 3. Attachment: stainless-steel clamp and hardware.
 - 4. Deflection: permit at least an 8° deflection from the centerline of the opening in any direction while maintaining a watertight connection.
 - 5. Seal: Joints shall be watertight under a 30 foot head of water.

2.7 CONCRETE ENCASEMENT AND CRADLES

- A. Concrete:
 - 1. Strength: 4,000 psi at 28 days.
 - 2. Air entrained.
 - 3. Finish: Rough troweled.
 - 4. Concrete shall be as specified.

2.8 MATERIALS

A. Bedding and Backfill:

1. General: No rock, boulders, stone or debris larger than four inches shall be allowed in the bedding or backfill material. Deficient or unsuitable bedding or backfill material shall be replaced or substituted with suitable bedding or backfill material. Excavated material intended for use as bedding or backfill shall not be used if exceedingly wet nor shall trenches be backfilled if flooded or excessively wet.
2. Stone: Stone used for pipe bedding and trench stabilization shall meet the gradation requirements of standard aggregate size No. 67.
3. Soil: Soils for bedding and backfill are described in the ASTM D2487 Figure 1 soils classification chart, and, for purposes of these Specifications, are grouped into five (5) categories as follows, according to their suitability
 - a. Class I Soil -Angular, 6 to 40 mm ($\frac{1}{4}$ " to $1\frac{1}{2}$ "), graded stone, including a number of fill materials that have regional significance, such as coral, slag, cinders, crushed stone, and crushed shells.
 - b. Class II Soil - Coarse sands and gravels with maximum particle size of 40 mm ($1\frac{1}{2}$ "), including variously graded sands and gravels containing small percentages of fines, generally granular and non-cohesive, either wet or dry. Soil types GW, GP, SW, and SP are included in this class.
 - c. Class III Soil - Fine sand and clayey gravels, including fine sands, sand clay mixtures, and gravel clay mixtures. Soil types GM, GC, SM, and SC are included in this class.
 - d. Class IV Soil Silt, silty clays, and clays, including inorganic clays and silts of medium to high plasticity and liquid limits. Soil types MH, ML, CH, and CL are included in this class. These materials are not recommended for bedding, haunching, or initial backfill.
 - e. Class V Soil - Includes the organic soils types OL, OH, and PT, as well as soils containing frozen earth, debris, rocks larger than $1\frac{1}{2}$ inches in diameter, and other foreign materials. These materials are not recommended for bedding, haunching, or initial backfill for any of the accepted pipe materials.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that excavation base is ready to receive Work of this Section.
- B. Verify that excavations, dimensions, and elevations are as indicated on Drawings.
- C. Existing Utilities
 1. All utility Owners shall be notified prior to excavation as required by the 1985 Underground Damage Prevention Act. Utility Owners who are members of NC OneCall may be notified by calling 811 (toll free) before any excavation or drilling. The CONTRACTOR will be fully responsible for damage to any utilities if the Owners have not been properly notified as required by the Underground Damage Prevention Act. All damage to such structures and pipelines and all damage to property or persons resulting from damage to such structures and pipelines shall be borne by the CONTRACTOR and shall be completely repaired within a reasonable time. No claim shall be made against the OWNER for damage or delay of the work on account of the proximity of, or the leakage from, such structures and pipelines. Where high pressure gas lines are to be crossed, they shall be uncovered by hand excavation methods before other excavation near them is started.

2. Where required by the Contract Documents, excavate to determine the precise location of utilities or other underground obstructions which are shown on the Plans and/or marked by the utility Owners. Such location and excavation shall be at least 500 feet ahead of construction, unless otherwise noted.
3. Utility Owners may, at their option, have representatives present to supervise excavation in the vicinity of their utilities. The cost of such supervision, if any, shall be borne by the CONTRACTOR.
4. When underground obstructions not shown on the Plans are encountered, promptly report the conflict to the ENGINEER and do not proceed with construction until the conflict is resolved.
5. Conflicts with underground utilities may necessitate changes in alignment and/or grade of this construction. All such changes will be approved by the ENGINEER before construction proceeds.

3.2 PREPARATION

- A. Preconstruction Site Photos:
 1. Take photographs along centerline of proposed pipe trench; minimum one photograph for each fifty (50) feet of pipe trench.
 2. Show mailboxes, curbing, lawns, driveways, signs, culverts, and other existing Site features.
 3. Include Project description, date taken, and sequential number on back of each photograph.
- B. Protect and support existing utilities and appurtenances.
- C. Inspect each pipe and fitting before and after installation; replace those found defective and remove from site. Provide proper equipment for lowering sections of pipe into trenches.
- D. Provide tools, implements, and facilities for the safe prosecution of pipe laying in accordance with manufacturer requirements and these specifications. All pipe and other materials used in the laying of pipe will be lowered into the trench piece by piece by means of suitable equipment in such a manner to prevent damage to the pipe, materials, to the protective coating on the pipe materials, and to provide a safe working condition to all personnel in the trench. Each piece of pipe being lowered into the trench shall be clean, sound and free from defects. It shall be laid on the prepared foundation, as specified elsewhere to produce a straight line on a uniform grade, each pipe being laid so as to form a smooth and straight inside flow line. Pipe shall be removed at any time if broken, injured or displaced in the process of laying same, or of backfilling the trench.
- E. When cutting short lengths of pipe, a pipe cutter, as recommended by the manufacturer, will be used and the cut shall be made at right angles to the centerline of the pipe. In the case of push on joints, the cut ends shall be tapered with a portable grinder, in accordance with manufacturer guidelines.

3.3 INSTALLATION

- A. Installing Pipe on Line and Grade:
 1. Excavate pipe trench as specified.
 2. Excavate to lines and grades as indicated on Drawings.
 3. Dewater excavations where required to maintain dry conditions and to preserve final grades at bottom of excavation.
 4. Provide sheeting and shoring as specified.

- B. Bedding and Backfill:
 - 1. Place bedding material (No. 67 stone) to establish the required invert elevation and pipe grade.
 - 2. Work bedding material carefully around pipe to ensure adequate haunching.
- C. PVC Pipe:
 - 1. After the joint has been made, backfill to top of pipe with No. 67 stone material. Do not allow the pipe to shift. Additional bedding requirements outlined in project drawings shall be followed.
- D. Ductile Iron Pipe:
 - 1. After joint has been made, backfill to top of pipe using Class I or Class II soils or No. 67 stone. Do not allow pipe to shift. Additional bedding requirements outlined in project drawings shall be followed.
- E. Backfill and Compaction:
 - 1. Backfill in 6 to 12-inch lifts. Tamp each lift carefully and uniformly so as to eliminate the possibility of lateral displacement of the pipeline.
 - 2. Compact pipe bedding and embedment material to 95% Standard Proctor.
- F. Piping:
 - 1. Pipe is to be installed in strict accordance with the manufacturer's recommendations and the contract specifications. The ENGINEER may augment any manufacturer's installation recommendations if, in his opinion, it will best serve the interest of the OWNER.
 - 2. Install pipe to grades and invert elevations indicated on Drawings.
 - 3. Begin at downstream end of system and progress upstream.
 - 4. Lay gravity sewer pipe with the bell ends in the upgrade direction.
 - 5. All pipe laid on a grade of twenty (20) percent or greater shall require thrust blocking or keying as shown on the drawings and standard details.
 - 6. Plug end of piping at end of each day and when work stops. No trench water or other material shall be permitted to enter the pipe. Clear interior of piping and manholes of dirt and debris as work progresses. If water is in the trench do not remove the plug until the danger of mud or earth entering the pipe has passed.
 - 7. Backfill and compact as specified.
 - 8. Do not displace or damage pipe when placing and compacting backfill.
 - 9. Ductile Iron Gravity Sewer
 - a. Comply with ASTM A746 and AWWA C600
 - 10. PVC Gravity Sewer
 - a. Comply with ASTM D2321 and ASTM F1668
 - b. Make joints to other pipe materials in accordance with the recommendations of the plastic pipe manufacturer.
- G. Connections to Existing Manholes:
 - 1. Connect to new manholes at precast inverts using the integrally cast neoprene boot and following manufacturer's guidelines. When new inverts must be made in manholes, use concrete core saw. Pneumatic hammers, chipping guns, or sledgehammers shall not be used to form new inverts.
 - 2. Install watertight neoprene gasket and seal annular space with nonshrink concrete grout.
 - 3. Prevent construction debris from entering existing sewer line when making connection.
- H. Wye Branches and Saddles:
 - 1. Concurrent with pipe-laying operations, install service connections using appurtenance indicated and at locations indicated on Drawings.
- I. Sanitary Laterals:

1. Unless otherwise shown on drawings, construct laterals from service connection to terminal point at right-of-way or edge of permanent easement. Terminate lateral with clean-out in accordance with detail.
2. Minimum Depth of Cover over Piping: unless indicated otherwise by authorities having jurisdiction, the minimum cover shall be in accordance with the NC State Plumbing Code, latest edition.
3. Minimum Separation Distance between Laterals: five (5) feet.
4. Minimum residential sewer service slope: 1/8" per foot for 3"-6" services.
5. Install watertight plug at termination of lateral, braced to withstand pipeline test pressure.

J. PE Encasement:

1. Encase piping in PE where indicated to prevent contact with surrounding backfill material.
2. Comply with AWWA C105.
3. Terminate encasement three (3) to six (6) inches above ground where pipe is exposed.

3.4 ABANDONMENT OF EXISTING SEWERS AND MANHOLES

- A. Manholes which are to be abandoned shall first have both influent and effluent lines plugged inside the manhole with watertight masonry or concrete. The manhole will then be filled with non-compressible material (crushed stone or materials approved by the ENGINEER), to a point not less than three (3) feet below the finish grade. The remainder of the manhole shall be broken down and removed. The excavation shall be backfilled to finish grade.
- B. Abandoned mains at active manholes shall be completely disconnected from the manhole by cutting the pipe outside the manhole and then plugging the abandoned main and the manhole wall with watertight masonry. The invert shall then be rebuilt to conform to new flow pattern.
- C. The minimum length of watertight masonry and concrete plugs will be the diameter of the abandoned pipe plus one (1) foot.

3.5 REINSTATING EXISTING SEWER SERVICE LINES

- A. Where existing sewer mains are being rehabilitated, sewer service lines shall be constructed for each property that is occupied by a business or dwelling if it is currently served by the system being rehabilitated.
- B. The CONTRACTOR shall be responsible to locate and connect all existing sewer service lines to the new main. In the event a service is missed during construction, return to the site and perform all work necessary to reinstate the connection. The CONTRACTOR will be compensated in accordance with the original contract unit pricing; however, re-mobilization to the site will not be paid for. In addition, the CONTRACTOR shall be responsible for any costs associated with a sanitary sewer overflow and associated damage to public or private property through the omission of reinstating an active sewer service.
- C. Service lines four (4) inches or less in diameter shall be tapped into the sewer main, not into a manhole. Service connections six (6) inches or greater shall only be made into an existing or proposed manhole, unless otherwise approved by the ENGINEER.

3.6 TOLERANCES

- A. Section 014000 - Quality Requirements: Requirements for tolerances.

- B. Maximum Variation from Indicated Slope: 1/8 inch in 10 feet.

3.7 FIELD QUALITY CONTROL

- A. Section 014000 - Quality Requirements: Requirements for inspecting and testing.
- B. Section 017000 - Execution and Closeout Requirements: Requirements for testing, adjusting, and balancing.
- C. Testing:
 - 1. Perform testing on Site sanitary sewage system according to authorities having jurisdiction. If there are no testing requirements indicated by authorities having jurisdiction, the testing shall be conducted in accordance with the following sections:
 - a. 330505.41 – Air Testing
 - b. 330505.43 – Mandrel Testing
 - 2. If tests indicate that Work does not meet specified requirements, remove Work, replace, and retest.

3.8 PROTECTION

- A. Section 017000 - Execution and Closeout Requirements: Requirements for protecting finished Work.
- B. Protect pipe and aggregate cover from damage or displacement until backfilling operation is in progress.
- C. Cap open ends of piping during periods of Work stoppage.

END OF SECTION 333111

SECTION 334200 - STORMWATER CONVEYANCE**PART 1 - GENERAL****1.1 SUMMARY****A. Section Includes:**

1. Stormwater drainage piping.
2. Manholes.
3. Catch basins.
4. Cleanouts.
5. Concrete encasement and cradles.
6. Bedding and cover materials.

1.2 REFERENCE STANDARDS**A. American Association of State Highway and Transportation Officials:**

1. AASHTO M36 – Standard Specification for Corrugated Steel Pipe, Metallic-Coated, for Sewers and Drains
2. AASHTO M252 - Standard Specification for Corrugated Polyethylene Drainage Pipe.
3. AASHTO M288 - Standard Specification for Geotextile Specification for Highway Applications.
4. AASHTO M294 - Standard Specification for Corrugated Polyethylene Pipe, 12- to 60-in. Diameter.

B. ASTM International:

1. ASTM A746 - Standard Specification for Ductile Iron Gravity Sewer Pipe.
2. ASTM C76 - Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe.
3. ASTM C443 - Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets.
4. ASTM C990 – Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants.
5. ASTM D2321 - Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications.

1.3 COORDINATION

- A. Section 013000 - Administrative Requirements: Requirements for coordination.
- B. Coordinate Work of this Section with termination of storm sewer connection outside building, trenching, and connection to, municipal sewer utility service.

1.4 SUBMITTALS

- A. Section 013300 - Submittal Procedures: Requirements for submittals.

- B. Product Data: Submit manufacturer information describing pipe, pipe accessories, and structures.
- C. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.
- D. Manufacturer Instructions: Submit special procedures required to install specified products.
- E. Field Quality-Control Submittals: Indicate results of CONTRACTOR-furnished tests and inspections.

1.5 CLOSEOUT SUBMITTALS

- A. Section 017000 - Execution and Closeout Requirements: Requirements for submittals.
- B. Project Record Documents: Record actual locations of pipe runs, connections, catch basins, cleanouts, and other storm structures. Record rim, invert out and invert in of structures.
- C. Identify and describe unexpected variations to subsoil conditions or discovery of uncharted utilities.

1.6 QUALITY ASSURANCE

- A. Perform Work according to standards of authorities having jurisdiction.

1.7 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing products specified in this Section with minimum three years' documented experience. If work is within the DOT right-of-way, then the manufacturer must be on the DOT approved vendors list.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Section 016000 - Product Requirements: Requirements for transporting, handling, storing, and protecting products.
- B. Inspection: Accept materials on Site in manufacturer's original packaging and inspect for damage.
- C. Store materials according to manufacturer instructions.
- D. Protection:
 - 1. Provide protection according to manufacturer instructions.

1.9 EXISTING CONDITIONS

- A. Field Measurements:
 - 1. Verify field measurements prior to fabrication.
 - 2. Indicate field measurements on Shop Drawings.

PART 2 - PRODUCTS**2.1 STORM DRAINAGE PIPING****A. Ductile-Iron Piping:**

1. Pipe:
 - a. Comply with ASTM A746, Class 50, unless indicated otherwise.
 - b. Type: As indicated on Drawings.
 - c. Diameter: As indicated on Drawings.
 - d. Ends: Bell and spigot.
2. Fittings: Ductile iron.
3. Joints:
 - a. Comply with ASTM A746.
 - b. Joint Devices: Rubber gasket.

B. Reinforced Concrete Piping:

1. Pipe:
 - a. Comply with ASTM C76, Class III, unless indicated otherwise.
 - b. Diameter: As indicated on Drawings.
 - c. End Connections: Bell and spigot.
2. Fittings: Reinforced concrete.
3. Joints:
 - a. Comply with ASTM C990 for joints using Preformed Flexible Joint Sealants.
 - b. Comply with ASTM C443 for joints using Rubber Gaskets.
 - c. Gaskets: Rubber, compression.

C. Corrugated PE Piping:

1. Pipe:
 - a. Comply with AASHTO M252 and M294, as applicable.
 - b. Type: Smooth Interior as indicated on Drawings.
 - c. Diameter: As indicated on Drawings.
2. Fittings: PE.
3. Joints: Comply with AASHTO M252, and AASHTO M294 as applicable.

D. Corrugated Steel Piping:

1. Pipe and Fittings:
 - a. Comply with AASHTO M36.
 - b. Nominal Diameter: As indicated on the Drawings.
 - c. Coating: Inside and outside, as indicated on Drawings.

2. Fittings: Corrugated steel.
3. Coupling Bands:
 - a. Material: Galvanized steel.
 - b. Minimum Size: 0.052 inch thick by 10 inches wide.
 - c. Connection: Two neoprene O-ring gaskets and two galvanized-steel bolts.

E. PVC Piping:

1. Pipe:
 - a. Comply with ASTM D3034, SDR 35.
 - b. Inside Nominal Diameter: As indicated on the Drawings
 - c. Style: Bell and spigot with rubber-ring sealed gasket joint.
2. Fittings: PVC.
3. Joints:
 - a. Comply with ASTM F477.
 - b. Gaskets: Elastomeric.

2.2 MANHOLES

- A. As specified in Section 330561 – Concrete Manholes.

2.3 CATCH BASINS, DROP INLETS, JUNCTION BOXES, YARD INLETS

- A. Shaft and Top Section:

1. Furnish materials according to Drawings and authorities having jurisdiction.

- B. Lids and Frames:

1. Furnish materials according to Drawings and authorities having jurisdiction.

2.4 CONCRETE ENCASEMENT AND CRADLES

- A. Concrete:

1. Description: concrete, as specified in Section 033000 - Cast-in-Place Concrete.
2. Compressive Strength: 3,000 psi at 28 days, unless otherwise indicated, concrete, rough troweled finish.

2.5 MATERIALS

- A. Bedding and Cover: As indicated on Drawings, Specifications and in accordance with authorities having jurisdiction.

2.6 ACCESSORIES

- A. Geotextile Filter Fabric:

1. Comply with AASHTO M288 for subsurface drainage.
2. Type: Class and type as indicated on Drawings.

- B. Underground Pipe Markers: In accordance with authorities having jurisdiction.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Section 017000 - Execution and Closeout Requirements: Requirements for installation examination.
- B. Verify that excavations, dimensions, and elevations are as indicated on Drawings.

3.2 PREPARATION

- A. Section 017000 - Execution and Closeout Requirements: Requirements for installation preparation.
- B. Correct over-excavation with bedding material as indicated on Drawings.
- C. Remove large stones and other hard matter that could damage piping or impede consistent backfilling or compaction.

3.3 INSTALLATION

- A. Excavation and Bedding:
 - 1. Excavate trench to depth indicated on Drawings below pipe invert, and as specified in Section 312316.13 - Trenching.
 - 2. Hand trim excavation for accurate placement of piping to indicated elevations.
 - 3. Place bedding material at trench bottom.
 - 4. Level materials in continuous layers as specified in Section 312316.13 - Trenching.
 - 5. Maintain optimum moisture content of bedding material to attain required compaction density.
 - 6. Place geotextile fabric over compacted bedding, as indicated on Drawings.
- B. Piping:
 - 1. Pipe, Fittings, and Accessories: Comply with ASTM D2321.
 - 2. Seal joints watertight.
 - 3. Place pipe on bedding as indicated on Drawings and in accordance with authorities having jurisdiction.
 - 4. Cradle bottom of pipe diameter to avoid point load as indicated on Drawings.
 - 5. Backfilling and Compaction:
 - a. As indicated on Drawings, as specified in Section 312323 - Fill and in accordance with authorities having jurisdiction.
 - b. Do not displace or damage pipe while compacting.
 - 6. Manholes: As specified in Section 330561 - Concrete Manholes.
 - 7. Pipe Markers: In accordance with authorities having jurisdiction.
 - 8. Install Site storm drainage system piping to within 5' feet of building.
 - 9. Installation Standards: Install Work according to authorities having jurisdiction standards.

- C. Catch Basins and Cleanouts:
 - 1. Installation Standards: Install Work according to the authority having jurisdiction.

3.4 TOLERANCES

- A. Section 014000 - Quality Requirements: Requirements for tolerances.
- B. Maximum Variation from Indicated Pipe Slope: 1/8 inch in 10 feet.

3.5 FIELD QUALITY CONTROL

- A. Section 014000 - Quality Requirements: Requirements for inspecting and testing.
- B. Section 017000 - Execution and Closeout Requirements: Requirements for testing, adjusting, and balancing.
- C. Request inspection by ENGINEER prior to and immediately after placing aggregate cover over pipe.
- D. Testing:
 - 1. Compaction Test:
 - a. Comply with recommendations of Geotechnical Engineer.
 - b. Testing Frequency: As required by Geotechnical Engineer and authorities having jurisdiction.
 - 2. Manholes: As specified in Section 330561 - Concrete Manholes.
 - 3. Piping: Inspect pipe for rips, tears, joint separations, soil migration, cracks, localized buckling, settlement, alignment, and deflection.
 - 4. If tests indicate that Work does not meet specified requirements, remove Work, replace, and retest.

3.6 PROTECTION

- A. Section 017000 - Execution and Closeout Requirements: Requirements for protecting finished Work.
- B. Protect pipe and aggregate cover from damage or displacement until backfilling operation is in progress.

END OF SECTION 334200