

PROJECT MANUAL



COLONIAL HEIGHTS HIGH SCHOOL RENOVATION/ADDITION COLONIAL HEIGHTS, VIRGINIA

MOSELEYARCHITECTS

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RICHMOND, VIRGINIA

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CIVIL ENGINEERING

RICHMOND, VIRGINIA

ECS MID-ATLANTIC, LLC

HAZARDOUS MATERIALS

RICHMOND, VIRGINIA

BID SET

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Volume 2

A/E's Proj. #611565
Set No.

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VOLUME 1

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004100	Bid Form
004313	Bid Bond (AIA Document A310)
004513	Contractor's Qualification Statement (AIA Document A305) Exhibit A: General Information Exhibit B: Financial and Performance Information Exhibit C: Project Specific Information Exhibit D: Contractor's Past Project Experience Exhibit E: Contractor's Past Project Experience, Continued
005213	Standard Form of Agreement Between Owner and Contractor (AIA Document A101)
006113	Performance Bond (AIA Document A312)
006113	Payment Bond (AIA Document A312)
007200	General Conditions of the Contract for Construction (AIA Document A201)

Prebid Question Form: (Use on-line process. To access go to
www.moseleyarchitects.com, "Bidding", "Submit a Question").

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Provisions of the Contract and of the Contract Documents apply to this Section.

1.2 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.
- F. The following are industry abbreviations for plastic materials:
1. ABS: Acrylonitrile-butadiene-styrene plastic.
 2. CPVC: Chlorinated polyvinyl chloride plastic.
 3. PE: Polyethylene plastic.
 4. PVC: Polyvinyl chloride plastic.
- G. The following are industry abbreviations for rubber materials:
1. EPDM: Ethylene-propylene-diene terpolymer rubber.
 2. NBR: Acrylonitrile-butadiene rubber.

1.3 SUBMITTALS

- A. Product Data: For the following:
1. Transition fittings.
 2. Dielectric fittings.

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3. Mechanical sleeve seals.
4. Escutcheons.

1.4 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.
- C. Electrical Characteristics for Plumbing 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.

1.5 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.
- B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.6 COORDINATION

- A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for plumbing 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 plumbing items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08 Section "Access Doors and Frames."

1.7 INTENT OF CONTRACT DOCUMENTS

- A. Plumbing drawings are diagrammatic, indicating general locations and arrangements of pipe, and equipment. Not necessarily indicating all offsets, conditions, and appurtenances required to provide clearances for maximum practical accessibility to perform maintenance.
- B. Coordinate work in order to achieve proper operation and to provide a maintainable installed condition.
- C. Notify the Architect's representative immediately of conditions which do not comply or will not produce this result.
- D. Indicated configurations were used to size pipes, pumps, expansion tanks and other devices. Install piping and equipment generally as indicated. Minor deviations are permitted in the course of necessary coordination. Major changes shall be submitted for approval by the Architect's representative. Additional fittings and offsets not shown on the drawings are expected, anticipated by the design, and shall be provided. If more than 5% of the indicated number of fittings are required or if one change in direction is within six inches of another change in direction and this "Z" shape is not indicated notify the Architect's representative immediately. Provide necessary additional fittings and offsets. Changes in pipe size shall be made only with written approval from the Architect's representative.

1.8 INSTALLED EXTRA PIPING AND EQUIPMENT

- A. The Plumbing Contractor (PC) shall include in his bid, labor and material for the installation of the following:
 - 1. 5 domestic water backflow prevention devices to serve coffee brewers, tea brewers, ice machines, and other general beverage dispensing equipment.
 - 2. 5 water supply boxes to serve ice making and water dispensing equipment and refrigerators.
 - 3. 5 interior, flush-mounted, loose-key operated, hose bibbs.
- B. Each of these items shall include 30' of ½" domestic water piping, fittings, valves, insulation, and accessories, etc... As needed throughout the project, the A/E or Owner will direct the Plumbing Contractor (PC) where these items are to be installed.
 - 1. There shall be a line item on the plumbing schedule of values titled "Extra Piping and Equipment".
 - 2. At project completion, a credit shall be given to the Owner for all unused extra piping and equipment. It shall be the Plumbing Contractor's responsibility to keep track and record of this work.

PART 2 - PRODUCTS

2.1 PIPE, TUBE, AND FITTINGS

- A. Refer to other 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 joining materials not listed below.
- B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions inside & outside pipe and:
 - 1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is otherwise 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-thick, unless otherwise indicated, and full-face or ring type, unless otherwise indicated.
- C. Solder Filler Metals: ASTM B 32, lead-free (95% Tin, 5% Antimony) alloy. Include water-flushable flux according to ASTM B 813.
- D. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAgl, silver alloy for refrigerant piping, unless otherwise indicated.
- E. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- F. Solvent Cements for Joining Plastic Piping:
 - 1. ABS Piping: ASTM D 2235.
 - 2. CPVC Piping: ASTM F 493.
 - 3. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
 - 4. PVC to ABS Piping Transition: ASTM D 3138.

2.3 MECHANICAL GROOVED JOINT COUPLINGS

- A. Manufacturer: Victaulic

- B. Description: Pipe joint consisting of a grooved pipe, EPDM gasket, steel housing, 2 bolts and 2 nuts.
- C. Gasket Material: Grade "E" EPDM suitable for use up to 250 degrees F.
- D. Housing: Carbon steel

2.4 DIELECTRIC FITTINGS

- A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.
- B. Insulating Material: Suitable for system fluid, pressure, and temperature.
- C. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150 or 300 psig working pressure, as required to suit system pressures.
 - 1. Available Manufacturers:
 - a. Capitol Manufacturing Co.
 - b. Central Plastics Company.
 - c. Epco Sales, Inc.
 - d. Watts Industries, Inc.; Water Products Div.
- D. Dielectric-Flange Kits: Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
 - 1. Available Manufacturers:
 - a. Advance Products & Systems, Inc.
 - b. Calpico, Inc.
 - c. Central Plastics Company.
 - d. Pipeline Seal and Insulator, Inc.
 - 2. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig minimum working pressure where required to suit system pressures.
- E. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F.
 - 1. Available Manufacturers:
 - a. Calpico, Inc.
 - b. Lochinvar Corp.

2.5 SLEEVES

- A. Galvanized-Steel Sheet: 0.0239-inch 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.
- E. Molded PE: Reusable, PE, tapered-cup-shaped, and smooth-outer surface with nailing flange for attaching to wooden forms.

2.6 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. One-Piece, Floor-Plate Type: Cast-iron floor plate.
- F. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

2.7 GROUT

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

PART 3 - EXECUTION

3.1 PLUMBING DEMOLITION

- A. Refer to Division 2 Sections "Site and Selective Demolition" for general demolition requirements and procedures.
- B. Disconnect, demolish, and remove plumbing systems, equipment, and components indicated to be removed.
 - 1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
 - 2. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.
 - 3. Equipment to Be Removed: Remove equipment and associated piping back to main unless otherwise indicated. Cap services.
 - 4. Equipment to Be Removed and Reinstalled: Disconnect and cap services. Remove, clean, and store equipment. When appropriate, reinstall, reconnect, and make equipment operational.
 - 5. Equipment to Be Removed and Salvaged: Remove equipment and associated piping back to main unless otherwise indicated. Cap services. Remove equipment, clean, and store as directed (May be off-site). Make available to owner at time of the owner's choosing.
- C. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

3.2 PIPING SYSTEMS - COMMON REQUIREMENTS

- A. Install piping according to the following and Division 22 Sections specifying piping systems.
- B. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
- C. 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.
- D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- E. Install piping to permit valve servicing.
- F. Install piping at the minimum slopes required by authorities having jurisdiction unless otherwise indicated.
- G. Install piping free of sags and bends.

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- 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 according to the following:
 - 1. Exposed, Interior Installations/Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
 - 2. Exposed, Interior Installations/Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish and set-screw.
 - 3. Exposed, Interior Installations/Insulated Piping: One-piece, cast-brass type with polished chrome-plated finish.
 - 4. Exposed, Interior Installations/Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with finish to match surrounding surfaces.
 - 5. Exposed, Interior Installations/Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece or split-casting, cast-brass type with finish to match surrounding surfaces.
 - 6. Exposed, Interior Installations/Piping in Unfinished Service Spaces: None, provide sealant.
 - 7. Exposed, Interior Installations/Piping in Equipment Rooms: None, provide sealant.
 - 8. Exposed, Interior Installations/Piping at Floor Penetrations in Equipment Rooms, Fan Rooms, or similar wet spaces: None - provide sealant and sleeve extending 2" above floor to prevent liquid leaking to floor below
- L. Sleeves are not required for core-drilled holes.
 - 1. Exception: Exposed, Interior Installations at Floor Penetrations in Equipment Rooms, Fan Rooms, or similar wet spaces.
- M. Permanent sleeves are not required for holes formed by removable PE sleeves.
 - 1. Exception: Exposed, Interior Installations at Floor Penetrations in Equipment Rooms, Fan Rooms, or similar wet spaces.
- N. Install sleeves for pipes passing through walls, floors, or roofs.
 - 1. Cut sleeves to length for mounting flush with both surfaces.
 - a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring.
 - 2. Install sleeves as walls and slabs are constructed.
 - a. PVC Pipe Sleeves: Permitted for pipes smaller than NPS 6 except aboveground, exterior-walls.
 - b. Steel Sheet Sleeves: Permitted for pipes NPS 6 and larger, penetrating gypsum-board partitions except aboveground, exterior-walls.

- c. Stack Sleeve Fittings: For pipes penetrating floors. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor. Seal space outside sleeve fittings with grout.
 - 3. Except for penetrations where mechanical sleeve seals are used, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 7 Section "Joint Sealants".
 - O. Aboveground Exterior Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for annular clear space required by the mechanical sleeve seal manufacturer between pipe and sleeve for installing mechanical sleeve seals.
 - 1. Install steel pipe for sleeves smaller than 6 inches in diameter.
 - 2. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter.
 - 3. 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.
 - 4. Sleeves from an approved sleeve seal manufacturer shall be acceptable.
 - P. Underground Exterior Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for annular clear space required by the mechanical sleeve seal manufacturer between pipe and sleeve for installing mechanical sleeve seals.
 - Q. 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.
 - R. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Section "Penetration Firestopping" for materials.
 - S. Verify final equipment locations for roughing-in.
 - T. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.
- 3.3 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.

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- 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.
- I. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
 - 1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
 - 2. ABS Piping: Join according to ASTM D 2235 and ASTM D 2661 Appendixes.
 - 3. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
 - 4. PVC Pressure Piping: Join schedule number ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D 2855.
 - 5. PVC Non-pressure Piping: Join according to ASTM D 2855.
 - 6. PVC to ABS Non-pressure Transition Fittings: Join according to ASTM D 3138 Appendix.
- J. Plastic Pressure Piping Gasketed Joints: Join according to ASTM D 3139.
- K. Plastic Non-pressure Piping Gasketed Joints: Join according to ASTM D 3212.
- L. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.
 - 1. Plain-End Pipe and Fittings: Use butt fusion.
 - 2. Plain-End Pipe and Socket Fittings: Use socket fusion.

- M. Fiberglass Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.
- N. Mechanical Joints: Prepare pipe ends and fittings, apply coupling, and join according to joint manufacturer's written instructions.

3.4 PIPING CONNECTIONS

- A. Make connections according to the following, unless otherwise indicated:
 - 1. Install unions, in piping 2" and smaller, one adjacent to each valve and at final connections to each piece of equipment.
 - 2. Install flanges, in piping NPS 2-1/2" and larger, adjacent to final connections to each piece of equipment.
 - 3. Install dielectric unions or flanges for connections of dissimilar metals.

3.5 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

- A. Install equipment to allow maximum possible headroom unless specific mounting heights are 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.

3.6 PAINTING

- A. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.7 HOUSEKEEPING PADS AND EQUIPMENT PADS

- A. Housekeeping pads and equipment pads: Anchor equipment to concrete according to equipment manufacturer's written instructions and according to seismic codes at project location.
 - 1. Construct concrete pads in accordance with drawing details.
 - 2. Details may be found on structural drawings. If details are not provided comply with the following:

- a. Housekeeping pads inside the building shall be 4" thick and 6" larger all around than supported equipment. Provide a 1" chamfer on all edges.
- b. If details are not provided, equipment pads outside the building shall be 8" thick with a 24" deep 12" wide turndown (footing) all around the outside edge of the pad. Provide welded wire mesh reinforcement. Pad shall be 12" larger all around than supported equipment.
- c. Install dowel rods to connect housekeeping pad to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the pad. Provide a 1" chamfer on all edges.
- d. Install epoxy-coated anchor bolts. For equipment on housekeeping pads bolts shall extend through housekeeping pad, and anchor into structural concrete floor.
- e. Place and secure anchor bolts using supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions for placement.
- f. Install anchor bolts to elevations required for proper attachment to supported equipment.
- g. Install anchor bolts according to anchor bolt manufacturer's written instructions.
- h. Use 3000-psi, 28-day compressive-strength concrete and reinforcement as specified in Section "Cast-in-Place Concrete".

3.8 ERECTION OF METAL SUPPORTS AND ANCHORAGES

- A. Refer to Section "Metal Fabrications" for structural steel.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor plumbing materials and equipment.
- C. Field Welding: Comply with AWS D1.1.

3.9 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.

3.10 EXCAVATION AND BACKFILL

- A. Excavation and backfill shall be as indicated in Division 1 specifications and on the drawings. If excavation and backfill is not otherwise indicated the following shall apply:
1. Excavate trenches to indicated gradients, lines, depths, and elevations.
 - a. Beyond the building perimeter, excavate trenches to allow installation of top of pipe below frost line.
 2. Excavate trenches to uniform widths to provide twelve inches clear on each side of pipe. Excavate trench walls vertically from trench bottom.
 3. Trench Bottoms: Excavate trench bottoms to provide flat surface. Place and compact six inches of sand. Excavate and shape sand to provide uniform bearing and support of pipes. Shape sand to provide continuous support for bells, joints, fittings, and barrels of pipes. Sand shall be free of projecting stones and sharp objects.
 4. Backfill and hand tamp to 95% proctor to six inches above the top of the pipe.
 5. Backfill and machine tamp the remainder of the trench to 95% proctor in twelve inch lifts.

END OF SECTION 220500

SECTION 220513 – MOTORS FOR PLUMBING EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Provisions of the Contract and of the Contract Documents apply to this Section.

1.2 SUBMITTALS

- A. Manufacturer's catalog and efficiency 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. Comply with NFPA 70.

1.4 COORDINATION

- A. Equip all motors with overload protection.
 - 1. Locate overload protection near the motor.
 - 2. Overload protection:
 - a. Locate between the circuit breaker/fuse provided under Division 26 and the motor windings.
 - b. Comply with one of the following:
 - 1) Locate in motor by motor manufacturer. (Design Standard)
 - 2) Locate separate overload device near motor.
 - 3) Locate in, or with, disconnect switch by equipment manufacturer. Provision of such switch shall not modify, change, or eliminate Division 26 requirements. Provide indicated disconnecting means.
- B. Coordinate features of motors, installed units, and accessory devices. Provide motors that are:
- C. Compatible with controller.
- D. Matched to torque and horsepower requirements of the load.
- E. Matched to ratings and characteristics of supply circuit and required control sequence.
- F. Coordinate motor support with requirements for driven load; access for maintenance and motor replacement; installation of accessories, belts, belt guards; and adjustment of sliding rails for belt tensioning.
- G. Belt tension must be wrench and socket adjustable.
- H. Belt tensioning device must accommodate adjustable sheaves.

PART 2 - PRODUCTS

2.1 MOTOR REQUIREMENTS

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- A. Motor requirements apply except as follows:
- B. Ratings, performance, or characteristics for a motor are specified in another Section or are scheduled on the drawings.
- C. Motor manufacturer requires ratings, performance, or characteristics, other than those specified to meet indicated performance.

2.2 MOTOR CHARACTERISTICS

- A. Frequency Rating: 60 Hz.
- B. Voltage Rating: NEMA standard voltage selected to operate on nominal circuit voltage to which motor is connected.
- C. Duty: Continuous at 105 deg F and 3300 feet above sea level.
- D. Capacity and Torque sufficient to:
 - 1. Start, accelerate, and operate connected load.
 - 2. Maintain designated speeds.
 - 3. Operate at installed altitude and environment.
 - 4. Operate with indicated operating sequence.
 - 5. Operate without exceeding nameplate ratings.
 - 6. Operate without utilizing service factor.
- E. Enclosure: Open drip-proof unless otherwise indicated.
- F. Minimum Service Factor: 1.15 unless otherwise indicated.

2.3 POLYPHASE MOTORS

- A. Description: NEMA MG 1, Design B, medium induction motor.
- B. Premium efficiency motors shall meet the following full load efficiency:

HP	ODP			TEFC		
	6 Pole	4 Pole	2 Pole	6 Pole	4 Pole	2 Pole
1	82.5	85.5	77.0	82.5	85.5	77.0
1.5	86.5	86.5	84.0	87.5	86.5	84.0
2	87.5	86.5	85.5	88.5	86.5	85.5
3	88.5	89.5	85.5	89.5	89.5	86.5
5	89.5	89.5	86.5	89.5	89.5	88.5
7.5	90.2	91.0	88.5	91.0	91.7	89.5
10	91.7	91.7	89.5	91.0	91.7	90.2
15	91.7	93.0	90.2	91.7	92.4	91.0
20	92.4	93.0	91.0	91.7	93.0	91.0
25	93.0	93.6	91.7	93.0	93.6	91.7
30	93.6	94.1	91.7	93.0	93.6	91.7
40	94.1	94.1	92.4	94.1	94.1	92.4
50	94.1	94.5	93.0	94.1	94.5	93.0
60	94.5	95.0	93.6	94.5	95.0	93.6
75	94.5	95.0	93.6	94.5	95.4	93.6
100	95.0	95.4	93.6	95.0	95.4	94.1
125	95.0	95.4	94.1	95.0	95.4	95.0

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150	95.4	95.8	94.1	95.8	95.8	95.0
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- C. Efficiency: Premium
- D. Stator: Copper windings, unless otherwise indicated.
- E. Rotor: Squirrel cage, unless otherwise indicated.
- F. Bearings: Double-shielded, prelubricated ball bearings suitable for radial and thrust loading.
- G. Temperature Rise: Match insulation rating, unless otherwise indicated.
- H. Insulation: Class F, unless otherwise indicated.
- I. Code Letter Designation: NEMA starting Code F or G.
- J. Enclosure: Cast iron.
- K. Finish: Gray enamel.
- L. Motors Used with Reduced-Inrush Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.
- M. Source Quality Control: Perform the following tests on each motor according to NEMA MG 1:
 - N. Measure winding resistance.
 - O. Read no-load current and speed at rated voltage and frequency.
 - P. Measure locked rotor current at rated frequency.
 - Q. Perform high-potential test.

PART 3 - EXECUTION

3.1 FIELD QUALITY CONTROL

- A. Perform the following:
 - 1. Run each motor with its controller at load.
 - 2. Demonstrate correct rotation, alignment, and speed.
 - 3. Test interlocks and control features for proper operation.
 - 4. Verify that current in each phase is within nameplate rating.
 - 5. Verify RPM is in accordance with nameplate.
 - 6. Where a generator is provided, run each motor on the generator with its controller and load. Demonstrate correct rotation, alignment, and speed.

3.2 ADJUSTING

- A. Align motors, bases, and shafts.

3.3 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.

END OF SECTION 220513

SECTION 220516 - EXPANSION FITTINGS AND LOOPS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Provisions of the Contract and of the Contract Documents apply to this Section.

1.2 PERFORMANCE REQUIREMENTS

- A. Compatibility: Products shall be suitable for piping service fluids, materials, working pressures, and temperatures.
- B. Capability: Products to absorb 200 percent of maximum axial movement between anchors.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Maintenance Data: For expansion joints to include in maintenance manuals.

1.4 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1 PACKLESS EXPANSION JOINTS

- A. Flexible-Hose Packless Expansion Joints:
 - 1. Available Manufacturers:
 - a. Flex-Hose Co., Inc.
 - b. Flexicraft Industries.
 - c. Flex Pression Ltd.
 - d. Metraflex, Inc.
 - e. Unisource Manufacturing, Inc.

2. Description: Manufactured assembly with inlet and outlet elbow fittings and two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose.
3. Flexible Hose: Corrugated-metal inner hoses and braided outer sheaths.
4. Expansion Joints for Copper Tubing NPS 2 and Smaller: Copper-alloy fittings with solder-joint end connections.
 - a. Bronze hoses and single-braid bronze sheaths with 450 psig at 70 deg F and 340 psig at 450 deg F ratings.
 - b. Bronze hoses and double-braid bronze sheaths with 700 psig at 70 deg F and 500 psig at 450 deg F ratings.
5. Expansion Joints for Copper Tubing 2-1/2" to 4": Copper-alloy fittings with threaded end connections.
 - a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 300 psig at 70 deg F and 225 psig at 450 deg F ratings.
 - b. Stainless-steel hoses and double-braid, stainless-steel sheaths with 420 psig at 70 deg F and 315 psig at 450 deg F ratings.

2.2 ALIGNMENT GUIDES AND ANCHORS

A. Alignment Guides:

1. Available Manufacturers:
 - a. Adscro Manufacturing LLC.
 - b. Advanced Thermal Systems, Inc.
 - c. Flex-Hose Co., Inc.
 - d. Flexicraft Industries.
 - e. Flex-Weld, Inc.
 - f. Hyspan Precision Products, Inc.
 - g. Metraflex, Inc.
 - h. Unisource Manufacturing, Inc.
2. Description: Steel, factory-fabricated alignment guide, with bolted two-section outer cylinder and base for attaching to structure; with two-section guiding spider for bolting to pipe.

B. Anchor Materials:

1. Steel Shapes and Plates: ASTM A 36/A 36M.
2. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel hex head.
3. Washers: ASTM F 844, steel, plain, flat washers.
4. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, with tension and shear capacities appropriate for application.
 - a. Stud: Threaded, zinc-coated carbon steel.

- b. Expansion Plug: Zinc-coated steel.
 - c. Washer and Nut: Zinc-coated steel.
5. Chemical Fasteners: Insert-type-stud, bonding-system anchor for use with hardened portland cement concrete, with tension and shear capacities appropriate for application.
- a. Bonding Material: ASTM C 881/C 881M, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
 - b. Stud: ASTM A 307, zinc-coated carbon steel with continuous thread on stud unless otherwise indicated.
 - c. Washer and Nut: Zinc-coated steel.

PART 3 - EXECUTION

3.1 EXPANSION-JOINT INSTALLATION

- A. Install expansion joints of sizes matching sizes of piping in which they are installed.
- B. Install metal-bellows expansion joints according to EJMA's "Standards of the Expansion Joint Manufacturers Association, Inc."
- C. Install rubber packless expansion joints according to FSA-NMEJ-702.

3.2 PIPE LOOP AND SWING CONNECTION INSTALLATION

- A. Connect risers and branch connections to mains with a minimum of 5 (five) pipe fittings including tee in main.
- B. Connect risers and branch connections to terminal units with a minimum of 4 (four) pipe fittings including tee in riser.
- C. Connect mains and branch connections to terminal units with a minimum of 4 (four) pipe fittings including tee in main.

3.3 ALIGNMENT-GUIDE AND ANCHOR INSTALLATION

- A. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.
- B. Install two guide(s) on each side of pipe expansion fittings and loops. Install guides nearest to expansion joint not more than four Insert number pipe diameters from expansion joint.
- C. Attach guides to pipe and secure guides to building structure.
- D. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

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- E. Anchor Attachments:
 - 1. Anchor Attachment to Steel Pipe: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
 - 2. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-69, Type 24, U-bolts bolted to anchor.

- F. Fabricate and install steel anchors by welding steel shapes, plates, and bars. Comply with ASME B31.9 and AWS D1.1/D1.1M.
 - 1. Anchor Attachment to Steel Structural Members: Attach by welding.
 - 2. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer's written instructions.

- G. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

END OF SECTION 220516

SECTION 220517 - SLEEVES AND SLEEVE SEALS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Provisions of the Contract and of the Contract Documents apply to this Section.

1.2 SUBMITTALS

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

PART 2 - PRODUCTS

2.1 SLEEVES

- A. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.
- B. Galvanized-Steel Wall Pipes: ASTM A 53/A 53M, Schedule 40, with plain ends and welded steel collar; zinc coated.
- C. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.
- D. Galvanized-Steel-Sheet Sleeves: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.

2.2 STACK-SLEEVE FITTINGS

- A. Available Manufacturers:
 - 1. Smith, Jay R. Mfg. Co.
 - 2. Wade
 - 3. Zurn Specification Drainage Operation; Zurn Plumbing Products Group.
- B. Description: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring, bolts, and nuts for membrane flashing.
 - 1. Underdeck Clamp: Clamping ring with setscrews.

2.3 MECHANICAL SLEEVE SEALS

- A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
1. Available Manufacturers:
 - a. Advance Products & Systems, Inc.
 - b. Calpico, Inc.
 - c. GPT, EnPro Industries
 - d. Metraflex Co.
 - e. Pipeline Seal and Insulator, Inc.
 2. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
 3. Pressure Plates: Plastic. Include two for each sealing element.
 4. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

- A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.
- B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.
1. Sleeves are not required for core-drilled holes.
- C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
 2. Cut sleeves to length for mounting flush with both surfaces.
 - a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.
 3. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.
- D. Install sleeves for pipes passing through interior partitions.
1. Cut sleeves to length for mounting flush with both surfaces.
 2. Install sleeves that are large enough to provide ¼" clear space between sleeve and pipe or pipe insulation.

3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants.

- E. Fire Ratings: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials.

3.2 STACK-SLEEVE-FITTING INSTALLATION

- A. Install stack-sleeve fittings in new slabs as slabs are constructed.
 1. Install fittings that are large enough to provide ¼" clear space between sleeve and pipe or pipe insulation.
 2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Division 07 Section "Sheet Metal Flashing and Trim."
 3. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level.
 4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
 5. Using grout, seal the space around outside of stack-sleeve fittings.
- B. Fire Rating: Maintain indicated fire rating at pipe penetrations. Seal pipe penetrations with firestop materials.

3.3 SLEEVE-SEAL SYSTEM INSTALLATION

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building unless otherwise indicated.
- B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.4 SLEEVE AND SLEEVE-SEAL SCHEDULE

- A. Use sleeves and sleeve seals for the following piping-penetration applications:
 1. Exterior Concrete Walls above Grade, below Grade, Concrete Slabs-on-Grade, and Concrete Slabs above Grade:
 - a. Piping Smaller Than 6": Cast-iron wall sleeves with sleeve-seal system.
 - 1) Select sleeve size to allow for one inch (1") annular clear space between piping and sleeve for installing sleeve-seal system.
 - b. Piping 6" and Larger: Galvanized-steel-pipe sleeves with sleeve-seal system.

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END OF SECTION 220517

SECTION 220519 - METERS AND GAGES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Provisions of the Contract and of the Contract Documents apply to this Section.

1.2 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Operation and Maintenance Data: For meters and gages to include in operation and maintenance manuals.

1.3 ABBREVIATIONS:

- A. AFF Above finished floor
- B. F Fahrenheit
- C. SS Stainless Steel

PART 2 - PRODUCTS

2.1 LIQUID-IN-GLASS THERMOMETERS

- A. Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:
 - 1. Available Manufacturers:
 - a. Flo Fab Inc.
 - b. Miljoco Corporation.
 - c. Palmer Wahl Instrumentation Group.
 - d. Tel-Tru Manufacturing Company.
 - e. Trevice, H. O. Co.
 - f. Weiss Instruments, Inc.
 - g. Winters Instruments - U.S.
 - 2. Standard: ASME B40.200.
 - 3. Case: Cast aluminum; 9-inch nominal size unless otherwise indicated.
 - 4. Case Form: Adjustable angle unless otherwise indicated.
 - 5. Tube: Glass with magnifying lens and blue or red organic liquid.
 - 6. Tube Background: Non-reflective aluminum with permanently etched scale markings graduated in degrees F.
 - 7. Window: Glass

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8. Stem: Aluminum length = 1/2 pipe diameter, 1/2 duct width or 12" whichever is less.
 - a. Air-Duct Installation: Provide ventilated shroud.
 - b. Thermowell Installation: Provide Bare stem.
9. Connector: 1-1/4 inches, with ASME B1.1 screw threads.
10. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

2.2 THERMOWELLS

A. Thermowells:

1. Standard: ASME B40.200.
2. Description: Pressure-tight, socket-type fitting made for insertion into threaded fitting.
3. Material: Brass.
4. Type: Stepped shank unless straight or tapered shank is indicated.
5. External Threads: NPS 1/2, NPS 3/4, or NPS 1, ASME B1.20.1 pipe threads.
6. Internal Threads: 1/2, 3/4, and 1 inch, with ASME B1.1 screw threads.
7. Bore: Diameter required to match thermometer bulb or stem.
8. Insertion Length: Length required to match thermometer bulb or stem.
9. Lagging Extension: Include on thermowells for insulated piping and tubing.
10. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

2.3 PRESSURE GAGES

A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:

1. Available Manufacturers:
 - a. AMETEK, Inc.; U.S. Gauge.
 - b. Ashcroft Inc.
 - c. Ernst Flow Industries.
 - d. Flo Fab Inc.
 - e. Marsh Bellofram.
 - f. Miljoco Corporation.
 - g. Noshok.
 - h. Palmer Wahl Instrumentation Group.
 - i. REOTEMP Instrument Corporation.
 - j. Tel-Tru Manufacturing Company.
 - k. Trerice, H. O. Co.
 - l. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
 - m. Weiss Instruments, Inc.
 - n. WIKA Instrument Corporation - USA.
 - o. Winters Instruments - U.S.
2. Standard: ASME B40.100.

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3. Case: Solid-front, lead-free, pressure relief type; stainless steel; 4-1/2-inch nominal diameter.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Brass, with NPS 1/4, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
6. Movement: Phosphor bronze.
7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi.
8. Pointer: Dark-colored metal.
9. Window: Glass.
10. Ring: Brass.
11. Accuracy: + or - 1.0 percent of full scale.

2.4 GAGE ATTACHMENTS

- A. Snubbers: ASME B40.100, brass; with NPS 1/4, ASME B1.20.1 pipe threads and porous-metal-type surge-dampening device. Include extension for use on insulated piping.
- B. Siphons: Loop-shaped section of brass pipe with NPS 1/4 pipe threads.
- C. Valves: Brass or stainless-steel needle, with NPS 1/4, ASME B1.20.1 pipe threads.

2.5 TEST PLUGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Flow Design, Inc.
 2. Miljoco Corporation.
 3. National Meter, Inc.
 4. Peterson Equipment Co., Inc.
 5. Sisco Manufacturing Company, Inc.
 6. Trerice, H. O. Co.
 7. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
 8. Weiss Instruments, Inc.
- B. Description: Test-station fitting made for insertion into piping tee fitting.
- C. Body: Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.
- D. Thread Size: NPS 1/2, ASME B1.20.1 pipe thread.
- E. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F.
- F. Core Inserts: Chlorosulfonated polyethylene synthetic and EPDM self-sealing rubber.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install thermowells with socket extending to center of pipe in piping tees.
- B. Install thermowells of sizes required to match thermometer connectors. Include bushings to match sizes.
- C. Install thermowells with extensions on insulated piping.
- D. Install direct-mounted thermometers in thermowells and adjust positions.
- E. Install pressure gages in piping tees located between 36" and 60" above finished floor unless otherwise indicated.
- F. Install valve and snubber for each pressure gage.
- G. Install test plugs in piping tees at locations indicated.
- H. Assemble and install connections, tubing, and accessories between flow-measuring elements and flowmeters according to manufacturer's written instructions.
- I. Install flowmeter elements in accessible positions in piping systems.
- J. Install permanent indicators on walls or brackets at 50" above finished floor unless otherwise indicated..
- K. Install connection fittings in accessible locations for attachment to portable indicators.
- L. Install thermometers in the following locations:
 - 1. Inlet and outlet of each water heater.
- M. Install pressure gages in the following locations:
 - 1. Inlet and outlet of each water heater.
 - 2. Suction and discharge of each pump.
- N. Install a test plug at each thermometer and pressure gauge.

3.2 THERMOMETER SCALE-RANGE SCHEDULE

- A. Scale Range for Domestic Cold-Water Piping: 0 to 100 F with 2-degree scale divisions.
- B. Scale Range for Domestic Hot-Water and Hot-Water Recirculation Piping 30 to 240 F with 2-degree scale divisions.

3.3 PRESSURE-GAGE SCALE-RANGE SCHEDULE

- A. Scale Range for Domestic Water Piping: 0 psi to 100 psi.
 - 1. Provide pressure scale range so that normal operating high and low pressures are within 25%-75% of the full scale range.

END OF SECTION 220519

SECTION 220523 – GENERAL DUTY VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Provisions of the Contract and of the Contract Documents apply to this Section.

1.2 DEFINITIONS

- A. The following are standard abbreviations for valves:
 1. CWP: Cold working pressure.
 2. EPDM: Ethylene-propylene-diene terpolymer rubber.
 3. MPTFE: Modified polytetrafluoroethylene plastic.
 4. NBR: Acrylonitrile-butadiene rubber.
 5. PTFE: Polytetrafluoroethylene plastic.
 6. RPTFE: Reinforced polytetrafluoroethylene plastic.
 7. SWP: Steam working pressure.
 8. TFE: Tetrafluoroethylene plastic.
 9. WOG: Water Oil Gas.

1.3 SUBMITTALS

- A. Product Data: For each type of valve proposed. Include body, seating, and trim materials; valve design; pressure and temperature classifications; end connections; arrangement; dimensions; and required clearances. Include proposed specialties and accessories.

1.4 QUALITY ASSURANCE

- A. ASME Compliance: ASME B31.1 for power piping valves and ASME B31.9 for building services piping valves.
 1. Exceptions: Domestic hot- and cold-water valves unless referenced.
- B. ASME Compliance for Ferrous Valves: ASME B16.10 and ASME B16.34 for dimension and design criteria.
- C. NSF Compliance:
 1. NSF 61 for valve materials for potable-water service.
 2. NSF 372 for Lead content requirements in drinking water system components.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Prepare valves for shipping as follows:
 1. Protect internal parts against rust and corrosion.

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2. Protect threads, flange faces, grooves, and weld ends.
 3. Set ball valves open to minimize exposure of functional surfaces.
 4. Set butterfly valves closed or slightly open.
 5. Block check valves in either closed or open position.
- B. Use the following precautions during storage:
1. Maintain valve end protection.
 2. Store valves indoors and maintain at higher than ambient dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.
- C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 VALVES, GENERAL

- A. Refer to Part 3 "Valve Applications" Article for applications of valves.
- B. Bronze & Brass: Shall be dezincification resistant. (Zinc content shall be less than 15%)
- C. Bronze Valves: 2" and smaller with threaded or soldered ends, unless otherwise indicated.
- D. Ferrous Valves: 2-1/2" and larger with flanged ends, unless otherwise indicated.
- E. Valve Pressure and Temperature Ratings: Not less than indicated for system pressure and temperature.
- F. Valve Sizes: Same as the larger of the upstream or downstream pipe, unless otherwise indicated.
- G. Valve Actuators:
1. As indicated in other Part 2 articles.
 2. Where indicated, provide a chain actuator.
 3. Chain Actuator: For attachment to valves of size and mounting height indicated.
 4. Wrench: For plug valves with square heads. Furnish Owner with 1 wrench for every 10 plug valves, for each size square plug head.
- H. Extended Valve Stems: Provide on insulated valves.
- I. Valve Flanges: Provide ASME B16.1 for cast-iron valves, ASME B16.5 for steel, and ASME B16.24 for bronze.
- J. Valve Grooved Ends: AWWA C606.
- K. Threaded: With threads according to ASME B1.20.1.
- L. Valve Bypass and Drain Connections: MSS SP-45.

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2.2 COPPER-ALLOY BALL VALVES

- A. Two-Piece, Copper-Alloy Ball Valves (Full Port) (1/4" to 2-1/2"):
1. Conbraco Industries-Apollo 77CLF series with stainless steel ball & stem (Un-insulated piping)
 2. Conbraco Industries-Apollo 77CLF series with stainless steel ball & stem. Provide 2 1/4" stem extension (Insulated piping)
 3. Other Manufacturers:
 - a. Milwaukee
 - b. Watts
 - c. Nibco
 4. Handle Nut: Zinc plated steel or 300 series stainless steel.
 5. Handle: Zinc plated steel, clear chromate plastic, or vinyl coated.
 6. Threaded Pack Gland: Brass ASTM B-16
 7. Packing: MPTFE or TFE
 8. Stem (Blowout Proof): ASTM A-276 type 316 stainless steel. Provide 2 1/4" stem extension for Insulated piping.
 9. Thrust Washer: MPTFE or RPTFE
 10. Ball: Full-port, ASTM A-276 Type 316 stainless steel.
 11. Seats: MPTFE or Reinforced TFE (RPTFE)
 12. Body: Bronze ASTM B-584 for solder or threaded connection.
 13. Body End Piece: Bronze ASTM B-584 for solder or threaded connection.
 14. Rating: 150 psig saturated steam, 600 psig non-shock cold water, oil, and gas.
 15. Conform To: MSS SP-110
- B. Two-Piece, Bronze Ball Valves UL listed for shut-off gas service (Up to 2 1/2"):
1. Conbraco Industries-Apollo 80-100 series (Un-insulated piping).
 2. Conbraco Industries-Apollo 80-100 series with stainless steel ball & stem. Provide 2 1/4" stem extension (Insulated piping)
 3. Other Manufacturers:
 - a. Milwaukee
 - b. Watts
 - c. Nibco
 4. Handle Nut: Zinc plated steel or 300 series stainless steel.
 5. Handle: Zinc plated steel, clear chromate plastic, or vinyl coated.
 6. Threaded Pack Gland: Brass ASTM B-16
 7. Packing: MPTFE or TFE
 8. Stem (Blowout Proof): ASTM A-276 type 316 stainless steel. Provide 2 1/4" stem extension for Insulated piping.
 9. Thrust Washer: MPTFE or RPTFE
 10. Ball: Brass ASTM B-16, chrome plated.
 11. Seats: MPTFE or Reinforced TFE (RPTFE)
 12. Body: Bronze ASTM B-584 for threaded connection.
 13. Body End Piece: Bronze ASTM B-584 for threaded connection.
 14. Rating: 150 psig saturated steam, 250 psi gas, vacuum service to 29".
 15. Conform To: MSS SP-110
- C. Two-Piece, Copper-Alloy Ball Valves (Full Port) (2-1/2" to 4"):
1. Conbraco Industries - Apollo 94ALF-A series with stainless steel ball & stem (Un-insulated piping)

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2. Conbraco Industries - Apollo 94ALF-A series with stainless steel ball & stem. Provide 2 ¼" stem extension (Insulated piping)
3. Other Manufacturers:
 - a. Milwaukee
 - b. Watts
 - c. Nibco.
4. Handle Nut: Zinc plated steel or 300 series stainless steel.
5. Handle: Zinc plated steel, clear chromate plastic, or vinyl coated.
6. Threaded Pack Gland: Brass ASTM B-16 Alloy 360
7. Packing: RPTFE or TFE
8. Stem (Blowout Proof): ASTM A-276 type 316 stainless steel. Provide 2 ¼" stem extension for Insulated piping.
9. Thrust Washer: MPTFE or Reinforced TFE
10. Ball: Full-port, ASTM A-276 Type 316 stainless steel.
11. Seats: MPTFE or Reinforced TFE
12. Body: Bronze ASTM B-584 for solder or threaded connection.
13. Body End Piece: Bronze ASTM B-584 for solder or threaded connection.
14. Rating: 150 psig saturated steam, 600 psig non-shock cold water, oil, and gas.
15. Conform To: MSS SP-110

2.3 LARGE GAS BALL VALVES (ABOVE 2 ½" to 10"):

- A. Carbon Steel ANSI class 150, flanged, standard port ball valve with stainless steel ball and stem.
 1. Conbraco Industries-Apollo 88A-140 series
 2. Other Manufacturers:
 - a. Milwaukee
 - b. Watts
 - c. Nibco
 3. Provide gear operator with oversized hand wheel.
 4. Packing Gland: ASTM A108 Type 1215
 5. Packing: RPTFE or TFE
 6. Stem (Blowout Proof): ASTM A108 Type 1215
 7. Ball: Standard-port, ASTM A-276 Type 316 stainless steel solid ball.
 8. Seats: RPTFE
 9. Thrust Washer: RPTFE.
 10. Body: Carbon steel ASTM A216 WCB.
 11. Body Nut: ASTM A194, grade 2H.
 12. UL (YRPV): Listed for gas shut-off service.
 13. Rating: 150 psig saturated steam

2.4 FERROUS-ALLOY BUTTERFLY VALVES

- A. General: Butterfly valves shall provide bi-directional bubble tight dead end service without a downstream flange.
- B. Wafer-lug type butterfly valves:
 1. Conbraco Industries-Apollo 141(wafer)/143(lug)

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2. Other Manufacturers:
 - a. Stockham
 - b. Demco
 - c. Nibco
 3. Shaft: ASTM A-582 Type 416 Stainless steel single piece through shaft.
 4. Collar Bushing: ASTM B-124 Brass or PTFE.
 5. Stem Seal: EPDM OR Buna-N Rubber
 6. Body Seal: EPDM Rubber
 7. Upper Bushing: CDA 122 Copper or PTFE
 8. Liner: EPDM Rubber
 9. Disc: ASTM B-148 alloy 954/955 aluminum bronze.
 10. Lower Bushing: CDA 122 copper or PTFE.
 11. Body Wafer: ASTM A-536 Ductile Iron or ASTM A-126 CL. B cast iron.
 12. Body Lug: ASTM A-536 Ductile Iron or ASTM A-126 CL. B cast iron.
 13. Ratings:
 - a. 2" through 12" 200 psig CWP.
 - b. 14" through 24" 150 psig CWP.
 14. Conform To: MSS SP-67, MSS SP-25, API-609
 15. Operator:
 - a. Valves up to and including 6": Lever-lock operator.
 - b. Valves 8" and larger: Self locking worm gear operator equipped with adjustable stops at open and shut positions.
- C. Grooved-End 300 psig butterfly valves:
1. Conbraco Industries-Apollo SJ-900N/SJ-900N-L
 2. Other Manufacturers:
 - a. Victaulic
 - b. Nibco
 3. Upper Stem: ASTM A-582 Type 416 Stainless steel.
 4. Upper Bearing: Split metal.
 5. O-Ring: EPDM
 6. Body: ASTM A-395 ductile iron with polyimide coating.
 7. Disc: ASTM A-395 ductile iron with EPDM encapsulation.
 8. Lower Bearing: Split metal.
 9. Dust Plug: PVC
 10. Rating: 300 psig CWP.
 11. Conform To: MSS SP-67
 12. Operator:
 - a. Valves up to and including 6": Lever-lock operator.
 - b. Valves 8" and larger: Self locking worm gear operator equipped with adjustable stops at open and shut positions.
- D. Flanged 200 psig butterfly valves:
1. Conbraco Industries-Apollo SJ-200
 2. Other Manufacturers:
 - a. Nibco
 3. Upper Stem: ASTM A-582 Type 416 Stainless steel.
 4. Upper Bushing: TFE over porous bronze, steel backed.
 5. O-Ring: EPDM
 6. Body: ASTM A-126 Class B cast iron with polyimide coating.

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7. Disc: ASTM A-395 ductile iron with EPDM encapsulation.
8. Lower Bushing: TFE over porous bronze, steel backed.
9. Lower Stem: ASTM A-582 Type 416 Stainless steel.
10. Dust Plug: PVC
11. Rating: 200 psig CWP.
12. Conform To: MSS SP-67 and MSS SP-25
13. Operator:
 - a. Valves up to and including 6": Lever-lock operator.
 - b. Valves 8" and larger: Self locking worm gear operator equipped with adjustable stops at open and shut positions.

E. Flanged 200 psig butterfly valves for Gas Service:

1. NIBCO Model FC-2765-0
2. Upper Stem: ASTM A-582 Type 416 Stainless steel.
3. Upper Bushing: TFE over porous bronze, steel backed.
4. O-Ring: EPDM
5. Body: ASTM A-126 Class B cast iron with polyimide coating.
6. Disc: ASTM A-395 ductile iron with EPDM encapsulation.
7. Lower Bushing: TFE over porous bronze, steel backed.
8. Lower Stem: ASTM A-582 Type 416 Stainless steel.
9. Dust Plug: PVC
10. Rating: 200 psig CWP.
11. Conform To: MSS SP-67 and MSS SP-25
12. Operator:
 - a. Valves up to and including 6": Lever-lock operator.
 - b. Valves 8" and larger: Self locking worm gear operator equipped with adjustable stops at open and shut positions.

2.5 BRONZE CHECK VALVES

A. Bronze, Horizontal Swing Check Valves:

1. Conbraco Industries-Apollo 161S/T
2. Other Manufacturers:
 - a. Milwaukee
 - b. Stockham
 - c. Nibco
3. Bonnet: ASTM B-62 bronze.
4. Body: ASTM B-62 bronze.
5. Hinge Pin: ASTM B-140 alloy C31400 bronze, or B-134 alloy C23000 bronze.
6. Disc Hanger:
 - a. Sizes 1/4" thru 3/4": Type 304 stainless steel.
 - b. Sizes 1" and larger: ASTM B-62 bronze.
7. Hanger Nut: ASTM B-16 bronze.
8. Disc Holder: ASTM B-62 bronze.
9. Seat Disc:
 - a. Water and Other Heat Transfer Fluids: ASTM B-62 bronze.
 - b. Steam: TFE
10. Seat Disc Nut: ASTM B-16 or B-62 bronze.
11. Hinge Pin Plug: ASTM B-140 alloy C31600 bronze.

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12. Seat Disc Washer (When Provided): ASTM B-98 alloy C65500 or B-103 bronze.
13. Rating: 125 psig SWP and 200 psig CWP.
14. Conform To: MSS SP-80

B. Bronze, Inline Spring Loaded Check Valves:

1. Conbraco Industries-Apollo 61-100 series
2. Other Manufacturers:
 - a. Milwaukee
 - b. Stockham
 - c. Nibco
3. Body: ASTM B-584 alloy C84400 bronze.
4. Retainer/Stem: ASTM B16 brass or ASTM A-582 alloy C30300 stainless steel.
5. Ball Check: RPTFE or
6. Disc Holder 316 Stainless steel
 - a. Disc:
 - 1) Water, Oil, Gas: Buna-N
 - 2) Steam: TFE
 - b. Seat Screw: ASTM A-276 alloy S43000 stainless steel.
 - c. Body End: ASTM B-584 alloy C84400 bronze.
 - d. Rating: 125 psig SWP and 250 psig CWP.
7. Guide: ASTM B16 Brass
8. Spring: Type 316 stainless steel.
9. Rating: 125 psig SWP and 400 psig WOG.

2.6 IRON BODY CHECK VALVES

A. Iron Body, Horizontal Swing Check Valves:

1. Conbraco Industries-Apollo 910F
2. Other Manufacturers:
 - a. Milwaukee
 - b. Stockham
 - c. Nibco
3. Body Bolt: ASTM A-307 steel.
4. Bonnet: ASTM A-126 class B cast iron.
5. Body Gasket: Synthetic Fibers.
6. Body Nut: ASTM A-307 steel
7. Side Plug: ASTM B-16 alloy C36000 Brass.
8. Hanger Pin: ASTM B-16 alloy C36000 Brass.
9. Hanger: ASTM B-584 alloy C84400 cast bronze.
10. Disc: ASTM B-584 alloy C84400 cast bronze or ASTM A-536 ductile iron w/bronze face ring.
11. Seat Ring: ASTM B-584 alloy C84400 cast bronze.
12. Disc Nut: ASTM B-16 alloy C36000.
13. Body: ASTM A-126 class B cast iron.
14. Disc Bolt: ASTM B-16 alloy C36000 Brass.
15. Disc Plate: ASTM A-126 class B cast iron.
16. Disc Cage: ASTM A-126 class B cast iron.
17. Rating: 125 psig SWP and 200 psig CWP.
18. Conform To: MSS SP-71 Type 1.

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- B. Grooved-End, Ductile-Iron Spring Assisted Check Valves: Apollo SJ-900N with EPDM disc seal.

- C. Spring Actuated Silent Check Valves:
 - 1. NIBCO Model F-910
 - 2. Other Manufacturers:
 - a. Milwaukee
 - b. Stockham
 - 3. Body: ASTM A48 class 35 cast iron.
 - 4. Seat: ASTM B-584 alloy C83600 (B) bronze.
 - 5. Disc: ASTM B-584 alloy C83600 bronze.
 - 6. Spring: Type 302 ASTM A313 stainless steel.
 - 7. Bushing:
 - a. 6" and Smaller: ASTM B-16 brass
 - b. 8" and Larger: ASTM B-584 alloy C83600 bronze.
 - 8. Set Screws: Type 304 ASTM A-276 stainless steel.
 - 9. Rating: 200 psig CWP.
 - 10. Conform To: MIL-V-18436F

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.
- B. Operate valves in positions from fully-open to fully-closed. Examine guides and seats made accessible by such operations.
- C. Examine threads on valve and mating pipe for form and cleanliness.
- D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.
- E. Do not attempt to repair defective valves; replace with new valves.

3.2 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.
- C. Install valves in horizontal piping with stem at or above center of pipe.

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- D. Install valves in position to allow full stem movement.
- E. Install chainwheels on operators for ball and butterfly valves 4" and larger and more than 96 inches above finished floor. Extend chains to 60 inches above finished floor.
- F. Install check valves for proper direction of flow and as follows:
 - 1. Swing Check Valves: In horizontal position with hinge pin level.
 - 2. Center-Guided and Plate-Type Check Valves: In horizontal or vertical position, between flanges.
 - 3. Lift Check Valves: With stem upright and plumb.

3.3 ADJUSTING

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

3.4 VALVE APPLICATIONS

- A. Refer to piping Sections for specific valve applications. If valve applications are not indicated, use the following:
 - 1. Shutoff Service: Ball or butterfly valves.
 - 2. Throttling Service: Ball or butterfly valves.
 - 3. Pump Discharge: Spring-loaded, lift-disc check valves and ball or butterfly valves.
- 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. Domestic Water Piping: Use the following types of valves:
 - 1. Valves, NPS 2" and Smaller: Two-Piece, Copper-Alloy Ball Valves (Full Port).
 - 2. Valves, NPS 2-1/2" and 3":
 - a. Two-piece or three-piece, Copper-Alloy Ball Valves (Full Port).
 - b. Wafer-Lug, grooved-end, or flanged butterfly valves.
 - 3. Valves, NPS 4" and Larger: Wafer-Lug, grooved-end, or flanged butterfly valves.
 - 4. Pump Discharge Check Valves (Horizontal or Vertical), NPS 2" and Smaller: Bronze, Inline Lift Check Valves.
 - 5. Horizontal Check Valves, NPS 2" and Smaller: Bronze, Horizontal Swing Check Valves.
 - 6. Vertical Check Valves, NPS 2" and Smaller: Bronze, Inline Lift Check Valves.
 - 7. Pump Discharge Check Valves (Horizontal or Vertical), NPS 2-1/2" and Larger: Grooved-End, Ductile-Iron Spring Assisted Check Valves or Spring Actuated Silent Check Valves.
 - 8. Horizontal Check Valves, NPS 2-1/2" and Larger: Bronze, Horizontal Swing Check Valves.
 - 9. Vertical Check Valves, NPS 2-1/2" and Larger: Grooved-End, Ductile-Iron Spring Assisted Check Valves or Spring Actuated Silent Check Valves.
- D. Gas Piping: Use the following types of valves:
 - 1. Valves, NPS 2" and Smaller: Two-Piece, Copper-Alloy Ball Valves (Full Port).

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2. Valves, NPS 2-1/2" and 3":
 - a. Two-piece or three-piece, Copper-Alloy Ball Valves (Full Port).
 - b. Wafer-Lug, grooved-end, or flanged butterfly valves.
3. Valves, NPS 4" and Larger: Wafer-Lug, grooved-end, or flanged butterfly valves.
4. Pump Discharge Check Valves (Horizontal or Vertical), NPS 2" and Smaller: Bronze, Inline Lift Check Valves.
5. Horizontal Check Valves, NPS 2" and Smaller: Bronze, Horizontal Swing Check Valves.
6. Vertical Check Valves, NPS 2" and Smaller: Bronze, Inline Lift Check Valves.
7. Pump Discharge Check Valves (Horizontal or Vertical), NPS 2-1/2" and Larger: Grooved-End, Ductile-Iron Spring Assisted Check Valves or Spring Actuated Silent Check Valves.
8. Horizontal Check Valves, NPS 2-1/2" and Larger: Bronze, Horizontal Swing Check Valves.
9. Vertical Check Valves, NPS 2-1/2" and Larger: Grooved-End, Ductile-Iron Spring Assisted Check Valves or Spring Actuated Silent Check Valves.

END OF SECTION 220523

SECTION 220529 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Provisions of the Contract and of the Contract Documents apply to this Section.

1.2 DEFINITIONS

- A. MSS: Manufacturers Standardization Society of the Valve and Fittings Industry Inc.
- B. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

1.3 PERFORMANCE REQUIREMENTS

- A. Design Requirement: Design trapeze pipe hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer where using methods other than indicated.
- B. Structural Performance: Hangers and supports for Plumbing piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.
 - 1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test medium.
 - 2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

1.4 QUALITY ASSURANCE

- A. Structural Steel 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.

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

- A. Carbon-Steel Pipe Hangers and Supports:

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1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

B. Copper Pipe Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel.

2.2 TRAPEZE PIPE HANGERS

- A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.
- B. Trapeze Pipe Hanger Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled channel systems.

1. Assemble and provide according to manufacturer's written instructions. Center piping on channel to evenly distribute load.
2. Pipe sizes and numbers shall be in accordance with the following:

TRAPEZE PIPE HANGER TABLE								
PIPE SIZE	4"	3"	2 ½"	2"	1 ½"	1 ¼"	1"	TOTAL # of PIPES
NUMBER OF PIPES PERMITTED IN ONE CHANNEL SUPPORT	2	0	0	0	0	0	0	2
	0	2	2	0	0	0	0	4
	0	2	0	4	0	0	0	6
	0	2	0	0	6	0	0	8
	0	0	4	2	0	0	0	6
	0	0	4	0	2	2	0	8
	0	0	4	0	0	8	0	12
	0	0	0	6	2	2	2	12
	0	0	0	8	0	2	0	10
	0	0	0	0	14	0	0	14
0	0	0	0	0	16	0	16	

Notes:

1. Piping larger than 4" in diameter is not permitted in a channel support system.
2. Channel support systems shall be limited to eight (8) pipes per channel and two (2) channels (levels) per support system.
3. Smaller pipes can be substituted for larger pipes. For example two ¾" pipes may be installed in lieu of two 1" pipes, or 2" in lieu of 3", etc.
4. Spacing shall be in accordance with requirements for the smallest supported pipe. Refer to other specification sections for spacing requirements. If spacing requirements are not indicated comply with MSS SP-69.

C. Metal Framing Systems:

1. Available Manufacturers:

- a. Anvil International; a subsidiary of Mueller Water Products Inc.
- b. Empire Industries, Inc.
- c. ERICO International Corporation.
- d. Haydon Corporation; H-Strut Division.
- e. NIBCO INC.
- f. PHD Manufacturing, Inc.
- g. PHS Industries, Inc.

2. Description: Shop- or field-fabricated pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.

3. Standard: Comply with MFMA-4.

4. Channels: Continuous slotted steel channel with in-turned lips.

5. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.

6. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

7. Coating: Zinc.

2.3 THERMAL-HANGER SHIELD INSERTS

A. Available Manufacturers:

1. Carpenter & Paterson, Inc.
2. Clement Support Services.
3. ERICO International Corporation.
4. National Pipe Hanger Corporation.
5. PHS Industries, Inc.
6. Pipe Shields, Inc.; a subsidiary of Piping Technology & Products, Inc.
7. Piping Technology & Products, Inc.
8. Rilco Manufacturing Co., Inc.
9. Value Engineered Products, Inc.

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- B. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with 100-psig or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig minimum compressive strength and vapor barrier.
- C. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate with 100-psig, ASTM C 552, Type II cellular glass with 100-psig, or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig minimum compressive strength.
- 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" beyond sheet metal shield for piping operating below ambient air temperature.

2.4 PIPE STANDS

- A. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.
 - 1. Available Manufacturers:
 - a. Cooper B-Line – Dura-Blok
 - b. MAPA Products
 - c. Mifab, Inc. – C-Port
 - d. Miro Industries, Inc.
 - e. OMG, Inc.
 - f. PHP Systems/Design
 - g. Pipe Prop
 - h. Roof Top Blox
 - 2. Provide pipe supports for supporting gas, condensate, refrigeration lines, or hydronic piping on flat roof surfaces. Support shall rest on roof surface without penetrating the roof surface. Supports for condensate piping shall be adjustable vertically to ensure pipe slopes as required.
- B. Compact Pipe Stand: One-piece plastic unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.
- C. Curb Mounted Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

2.5 EQUIPMENT SUPPORTS

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

2.6 MISCELLANEOUS MATERIALS

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

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

- A. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Provide hangers, supports, clamps, and attachments as required to properly support piping from the building structure.
- B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69, MSS SP-89, and Table above. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.
- 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: Provide in pipe hanger or shield for insulated piping.
- E. Pipe Stand Installation: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
- F. Provide hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
- G. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
- H. Provide hangers and supports to allow controlled thermal 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. Provide lateral bracing with pipe hangers and supports to prevent swaying.
- J. Provide building attachments within concrete slabs or attach to structural steel. Building attachments may not used on steel joists unless otherwise indicated. Provide additional attachments at concentrated loads, including valves, flanges, and strainers, 2-1/2" and larger and at changes in direction of piping. Provide concrete inserts before concrete is placed; fasten inserts to forms and provide reinforcing bars through openings at top of inserts.

- K. Load Distribution: Provide hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- L. Pipe Slopes: Provide hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.
- M. Insulated Piping:
 - 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: Provide thermal-hanger shield insert with clamp sized to match OD of insert.
 - c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
 - 2. Provide MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
 - 3. Provide 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. Pipe ¼" to 3-½": 12 inches long and 0.048 inch thick.
 - b. Pipe 4": 12 inches long and 0.06 inch thick.
 - c. Pipe 5" and 6": 18 inches long and 0.06 inch thick.
 - d. Pipe 8" to 14": 24 inches long and 0.075 inch thick.
 - 5. Pipes 8" and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
 - 6. Thermal-Hanger Shields: Provide with insulation same thickness as piping insulation.

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 bearing surface smooth.
- C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.3 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/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:

1. Provide 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 so 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.
- B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.5 PAINTING

- A. Touchup: Unless otherwise indicated clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Provide 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 a minimum dry film thickness of 2.0 mils.
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and immediately apply galvanizing-repair paint. Paint shall comply with ASTM A 780.

3.6 HANGER AND SUPPORT SCHEDULE

- A. Specific hanger and support requirements are 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. Provide hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.
- D. Provide nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- E. Provide copper-plated pipe hangers and copper attachments for copper piping and tubing.
- F. Provide padded hangers for piping that is subject to scratching.
- G. Provide thermal-hanger shield inserts for insulated piping and tubing.
- H. Horizontal-Piping Hangers and Supports: Unless otherwise indicated provide the following:

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1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of stationary pipes ½” to 30”.
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F pipes 4” to 14”, requiring up to 4” of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes ¾” to 14”, requiring clamp flexibility and up to 4 inches of insulation.
4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes ½” to 14” if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes ½” to 4”, to allow off-center closure for hanger installation before pipe erection.
6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes ¾” to 8”.
7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes ½” to 8”.
8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes ½” to 8”.
9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes ½” to 8”.
10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes ½” to 8”.
11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS ½” to 3”.
12. U-Bolts (MSS Type 24): For support of heavy pipes ½” to 14”.
13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
14. Pipe Saddle Supports (MSS Type 36): For support of pipes 4” to 14”, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes 4” to 14”, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes 2-½” to 14” if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes 1” to 14”, from two rods if longitudinal movement caused by expansion and contraction might occur.
18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes 2-½” to 14”, from single rod if horizontal movement caused by expansion and contraction might occur.
19. Complete Pipe Rolls (MSS Type 44): For support of pipes 2” to 14” if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes 2” to 14” if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes 2” to 14” if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

I. Vertical-Piping Clamps: Unless otherwise indicated provide the following:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers ¾” to 14”.

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2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers $\frac{3}{4}$ " to 14" if longer ends are required for riser clamps.

J. Hanger-Rod Attachments: Unless otherwise indicated provide the following:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.
6. Flat Plate, Double Nut, and Washer as Detailed on Structural Drawings: For attaching to bar joists. Method of attachment to bar joists must be approved by the structural engineer and joist manufacturer.

K. Building Attachments: Unless otherwise indicated provide the following:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Flat Plate, Double Nuts, and Washer as Detailed on Structural Drawings: For use under roof installations with bar-joist construction to attach to bottom chord of joist.
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. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Provide one of the following for indicated loads:
 - a. Light (MSS Type 31): 750 lb.
 - b. Medium (MSS Type 32): 1500 lb.
 - c. Heavy (MSS Type 33): 3000 lb.
13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

L. Saddles and Shields: Unless otherwise indicated provide the followings:

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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.
- M. Spring Hangers and Supports: Unless otherwise indicated provide the following:
1. Restraint-Control Devices (MSS Type 47): To control pipe movement.
 2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
 3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
 4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
 5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
 6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
 7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
 8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
 - a. Horizontal (MSS Type 54): Mounted horizontally.
 - b. Vertical (MSS Type 55): Mounted vertically.
 - c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.
- N. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.
- O. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.
- P. Provide powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where indicated in concrete construction.

END OF SECTION 220529

SECTION 220553 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Provisions of the Contract and of the Contract Documents apply to this Section.

1.2 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.
- C. Valve Schedules: For each piping system to include in maintenance manuals.
- D. 1/16" = 1'-0" scale drawing showing all valve locations to include in maintenance manuals.

1.3 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.

1.4 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 locations of access panels and doors.
- C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

- A. Metal Labels for Equipment:
 - 1. Material and Thickness: Brass, Aluminum, or anodized aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
 - 2. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

3. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
4. Fasteners: Stainless-steel rivets or self-tapping screws.
5. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16-inch-thick, and having predrilled holes for attachment hardware.
2. Letter Color: White.
3. Background Color: Black.
4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
7. Fasteners: Stainless-steel rivets or self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

C. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified.

D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

- A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16-inch-thick, and having predrilled holes for attachment hardware.
- B. Letter Color: White.
- C. Background Color: Red.
- D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
- E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

- F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
- G. Fasteners: Stainless-steel rivets or self-tapping screws.
- H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- I. Label Content: Include caution and warning information, plus emergency notification instructions.

2.3 PIPE LABELS

- A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.
- B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.
- C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
- D. 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 high.

2.4 STENCILS

- A. Stencils: Prepared with letter sizes according to ASME A13.1 for piping; minimum letter height of 1-1/4 inches for ducts; and minimum letter height of 3/4 inch for access panel and door markers, equipment markers, equipment signs, and similar operational instructions.
 - 1. Stencil Material: Metal or fiberboard.
 - 2. Stencil Paint: Exterior, gloss, black, unless otherwise indicated. Paint shall be low VOC and shall meet the requirements of section 09910. Paint may be in pressurized spray-can form.
 - 3. Identification Paint: Exterior, in colors according to ASME A13.1, unless otherwise indicated. Paint shall be low VOC and shall meet the requirements of section 09910.

2.5 VALVE TAGS

- A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers, numbering scheme approved by Architect. Provide 5/32-inch hole for fastener.
 - 1. Material: 0.032-inch-thick brass or

2. Material: 0.0375-inch- thick stainless steel or
 3. Material: 3/32-inch- thick laminated plastic with 2 black surfaces and white inner layer.
- B. Valve-Tag Fasteners: Brass wire-link or beaded chain; or S-hook.

2.6 VALVE SCHEDULES

- A. Valve Schedules: For each piping system, on standard-size 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-Schedule Frames: Glazed display frame for removable mounting on masonry walls for each page of valve schedule. Include mounting screws and hangers.
 2. Frame: Finished hardwood or extruded aluminum.
 3. Glazing: ASTM C 1036, Type I, Class 1, Glazing Quality B, 2.5-mm, single-thickness glass.

2.7 VALVE PLAN

- A. Valve Plan: Prepare a scale drawing. Provide the location and identity of each valve.
1. Valve Plan Frames: Glazed display frame for removable mounting on masonry walls for each page of valve plan. Include mounting screws and hangers.
 2. Frame: Finished hardwood or extruded aluminum.
 3. Glazing: ASTM C 1036, Type I, Class 1, Glazing Quality B, 2.5-mm, single-thickness glass.

2.8 WARNING TAGS

- A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.
1. Size: 3 by 5-1/4 inches minimum.
 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 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 EQUIPMENT LABEL INSTALLATION

- A. Install and permanently fasten equipment nameplates on each major item of plumbing equipment that does not have nameplate or has a nameplate that is damaged or located where not easily visible. Locate nameplates where easily visible. Include nameplates for the following general categories of equipment:
 - 1. Fuel-burning units.
 - 2. Pumps, compressors, and other motor-driven equipment.
 - 3. Heat exchangers and similar equipment.
 - 4. Water heaters and storage tanks.
- B. Install equipment markers with permanent adhesive on or near each major item of mechanical equipment. Data required for markers may be included on signs, and markers may be omitted if both are indicated.
 - 1. Letter Size: Minimum 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
 - 2. Data: Distinguish among multiple units, indicate operational requirements, indicate safety and emergency precautions, warn of hazards and improper operations, and identify units.
 - 3. Locate markers where accessible and visible. Include markers for the following general categories of equipment:
 - a. Main control and operating valves, including safety devices and hazardous units such as gas outlets.
 - b. Meters, gages, and thermometers.
 - c. Fuel-burning units.
 - d. Pumps, compressors, and other motor-driven equipment.
 - e. Heat exchangers and similar equipment.
 - f. Water heaters and storage tanks.
- C. Stenciled Equipment Marker Option: Stenciled markers may be provided instead of laminated-plastic equipment markers, at Installer's option, if lettering larger than 1-inch high is needed for proper identification because of distance from normal location of required identification.
- D. Install equipment signs with screws or permanent adhesive on or near each major item of mechanical equipment. Locate signs where easily visible.

1. Identify mechanical equipment with equipment markers in the following color codes:
 - a. Green: For cooling equipment and components.
 - b. Yellow: For heating equipment and components.
 - c. Orange: For combination cooling and heating equipment and components.
 - d. Brown: For energy-reclamation equipment and components.
 - e. Blue: For equipment not listed in a through d
 2. Letter Size: Minimum 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
 3. Data: Distinguish among multiple units, indicate operational requirements, indicate safety and emergency precautions, warn of hazards and improper operations, and identify units.
- E. Stenciled Equipment Sign Option: Stenciled signs may be provided instead of laminated-plastic equipment signs, at Installer's option, if lettering larger than 1-inch high is needed for proper identification because of distance from normal location of required identification.
- F. Install access panel markers with screws on equipment access panels.

3.3 PIPE LABEL INSTALLATION

- A. Piping Color-Coding: Painting of piping is specified in other sections.
- B. Stenciled Pipe Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels with painted, color-coded bands or rectangles on each piping system.
1. Identification Paint: Use for contrasting background.
 2. Stencil Paint: Use for pipe marking.
- C. 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. 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 inaccessible 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 25 feet.
 7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.
- D. Pipe Label Color Schedule:
1. Domestic Cold Water Piping:

- a. Background Color: Green.
 - b. Letter Color: White.
2. Domestic Hot Water and Hot Water Return Piping:
- a. Background Color: Green.
 - b. Letter Color: White.
3. Sanitary Waste and Storm Drainage Piping:
- a. Background Color: Green.
 - b. Letter Color: White.
4. Natural Gas Piping:
- a. Background Color: Yellow.
 - b. Letter Color: Black.

3.4 VALVE-TAG INSTALLATION

- A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; plumbing fixture supply stops; shutoff valves; faucets; convenience and lawn-watering hose connections; and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.
- B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following:
 1. Valve-Tag Size and Shape:
 - a. Domestic Cold Water: 1 ½", round.
 - b. Domestic Hot Water: 1 ½", round.
 - c. Domestic Hot Water Recirculation: 1 ½", round.
 - d. Natural Gas: 2", round.
 2. Valve-Tag Color:
 - a. Domestic Cold Water: Blue.
 - b. Domestic Hot Water: Red.
 - c. Domestic Hot Water Recirculation: Red.
 - d. Natural Gas: Yellow.
 3. Letter Color:
 - a. Domestic Cold Water: Black.
 - b. Domestic Hot Water: White.
 - c. Domestic Hot Water Recirculation: White.
 - d. Natural Gas: 2", Black.

3.5 VALVE SCHEDULE INSTALLATION

- A. Mount valve schedules on wall in accessible location in each major equipment room and where directed by owner.

3.6 VALVE PLAN INSTALLATION

- A. Mount valve plans on wall in accessible location in each major equipment room and where directed by owner.

3.7 WARNING-TAG INSTALLATION

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

3.8 ADJUSTING

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

3.9 CLEANING

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

END OF SECTION 220553

SECTION 220700 - PLUMBING INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Provisions of the Contract and of the Contract Documents apply to this Section.

1.2 DEFINITIONS

- A. Outdoor pipe: Pipe located outside the building insulation envelope.
- B. Plenum: An unoccupied space or void, on the conditioned side of the building insulation and vapor barrier, being used to return conditioned air to the inlet side of a return or exhaust fan either directly or via a duct connection. An example would be a space with air handling light fixtures or openings in the ceiling used to transport air through the ceiling and then to an open duct located above the ceiling in another location.
- C. Indirectly Conditioned Space: A space having no direct conditioning but, due to air movement induced by an exhaust, or return opening, is conditioned by makeup air from an adjacent space. An example would be a small toilet. Boiler rooms, fan rooms, and mechanical rooms do not qualify as indirectly conditioned spaces.
- D. Inside the Building Insulation Envelope: For the purposes of this section, boiler rooms, fan rooms, and mechanical rooms are considered to be OUTSIDE the building insulation envelope.
- E. Exposed: Visible from any angle without removal of building element or equipment.
- F. Concealed: Enclosed in building element or above ceiling such that it is not visible from any angle without removal of building element or equipment.

1.3 SUBMITTALS

- A. Product Data: Identify thermal conductivity, thickness, and jackets (both factory and field applied, if any), for each type of product indicated.
- B. Shop Drawings: Show fabrication and installation details for the following:
 - 1. Detail application of removable insulation covers.
 - 2. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
 - 3. Detail attachment and covering of heat tracing inside insulation.
 - 4. Detail insulation application at pipe expansion joints for each type of insulation.
 - 5. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
 - 6. Detail removable insulation at piping specialties, equipment connections, and access panels.
 - 7. Detail application of field-applied jackets.
 - 8. Detail application at linkages of control devices.
 - 9. Detail field application for each equipment type.

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.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Ship insulation materials in containers marked by manufacturer with type, grade, and maximum use temperature.
- B. Ship Insulated Piping System Components on pallets and wood supports. Securely fasten and protect from damage. Store off the ground and cover with opaque waterproof tarp to protect materials from sunlight and rain.

1.6 COORDINATION

- A. Coordinate size and location of supports, hangers, and insulation shields specified in Section "Hangers and Supports for HVAC Piping and Equipment."
- B. Coordinate clearance requirements with piping installer for piping insulation, duct installer for duct insulation, and equipment installer for equipment insulation.
- C. Maintain clearances required for maintenance.
- D. Coordinate installation and testing of heat tracing.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers:
1. Mineral-Fiber Insulation:
 - a. CertainTeed Manson.
 - b. Johns Manville
 - c. Knauf FiberGlass GmbH.
 - d. Owens-Corning Fiberglas Corp.
 - e. Schuller International, Inc.
 2. Flexible Elastomeric Thermal Insulation:
 - a. Armstrong World Industries, Inc.
 - b. Rubatex Corp.
 3. Polyolefin Insulation:
 - a. Armstrong World Industries, Inc.
 - b. IMCOA.
 4. Closed-Cell Phenolic-Foam Insulation:

- a. Kooltherm Insulation Products, Ltd.
- 5. Removable Insulation Covers:
 - a. Advance Thermal Corp.

2.2 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. Mineral-Fiber Board: Glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IB, with factory applied FSK Jacket. Meet the requirements of ASTM C 1290, Type III, inorganic glass fibers bonded by a thermosetting resin to maximum service temperature of 250°F. Faced insulation shall not exceed 25 Flame Spread, 50 Smoke Developed when tested in accordance with ASTM E84.
- G. Semi-Rigid Mineral-Fiber Board: Glass fibers bonded with a thermosetting resin. Comply with ASTM C 1136, Type I, II, III, & IV with factory applied all-service jacket (ASJ) or Type II, IV with factory applied Foil Scrim Kraft (FSK) jacket.
- H. Mineral-Fiber Blanket with Factory Applied FSK Jacket: Meet the requirements of ASTM C 1290, Type III, inorganic glass fibers bonded by a thermosetting resin with a multi-purpose foil-scrim kraft (FSK) jacket to maximum service temperature of 250°F. FSK shall meet the requirements of ASTM C 1136, Type II, when surface burning characteristics are determined in accordance with ASTM E 84 with the foil surface of the material exposed to the flame as it is in the final composite. Composite (insulation, facing and adhesive) shall not exceed 25 Flame Spread, 50 Smoke Developed when tested in accordance with ASTM E 84. Insulation properties shall be as follows:
 - 1. Thickness: 1-1/2"
 - a. Density: 0.75 pcf
 - b. Minimum uncompressed R value: 5.0
 - c. Minimum installed R value assuming 25% compression: 4.0
 - 2. Thickness: 2"
 - a. Density: 1.0 pcf
 - b. Minimum uncompressed R value: 7.4
 - c. Minimum installed R value assuming 25% compression: 6.0
 - 3. Alternate to 2" 1.0 pcf: Thickness: 2.2"
 - a. Density: 0.75 pcf
 - b. Minimum uncompressed R value: 7.4
 - c. Minimum installed R value assuming 25% compression: 6.0
 - 4. Thickness: 3"
 - a. Density: 0.75 pcf

- b. Minimum uncompressed R value: 10.0
 - c. Minimum installed R value assuming 25% compression: 8.3
- I. Medium Temperature Mineral-Fiber Blanket for Operating Temperatures from 250 to 850 deg F: Glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II, without facing and with all-service jacket manufactured from kraft paper, reinforcing scrim, aluminum foil, and vinyl film.
 - J. High Temperature Mineral-Fiber Blanket for Temperatures above 850 deg F: Glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type V, without facing and with all-service jacket manufactured from kraft paper, reinforcing scrim, aluminum foil, and vinyl film.
 - K. Mineral-Fiber Pipe Insulation: Glass fibers bonded with a thermosetting resin complying with the following:
 - 1. Preformed Pipe Insulation: Comply with ASTM C 547, Type 1, with factory-applied, all-purpose, vapor-retarder jacket.
 - 2. Semi-Rigid Mineral-Fiber Board: Glass fibers bonded with a thermosetting resin. Comply with ASTM C 1136, Type I, II, III, IV with factory applied all-service jacket (ASJ) or Type II, IV with factory applied Foil Scrim Kraft (FSK) jacket.
 - 3. Blanket Insulation: Comply with ASTM C 553, Type II, without facing.
 - 4. Mineral-Fiber Insulating Cements: Comply with ASTM C 195.
 - 5. Expanded or Exfoliated Vermiculite Insulating Cements: Comply with ASTM C 196.
 - 6. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449/C 449M.
 - L. 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. Adhesive: As recommended by insulation material manufacturer.
 - 2. Ultraviolet-Protective Coating: As recommended by insulation manufacturer.
 - M. Closed-Cell Phenolic-Foam: Block insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type II, Grade 1.
 - N. Prefabricated Thermal Insulating Fitting Covers: Comply with ASTM C 450 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.
- 2.3 FIELD-APPLIED JACKETS
- A. General: ASTM C 921, Type 1, unless otherwise indicated.
 - B. Glass Cloth: Woven glass-fiber fabric, plain weave, minimum 8 ounces per square yard.
 - C. Foil and Paper Jacket: Laminated, glass-fiber-reinforced, flame-retardant kraft paper and aluminum foil.
 - D. PVC Jacket: High-impact, ultraviolet-resistant PVC; 20 mils thick; roll stock ready for shop or field cutting and forming.
 - 1. Adhesive: As recommended by insulation material manufacturer.
 - 2. PVC Duct Jacket Color: White or gray.
 - 3. PVC Pipe Jacket Color: Color-code piping jackets based on materials contained within the piping system.

- E. Aluminum Jacket: Deep corrugated sheets manufactured from aluminum alloy complying with ASTM B 209, and having an integrally bonded moisture barrier over entire surface in contact with insulation. Factory cut and rolled to indicated sizes. Comply with ASTM B 209, 3003 alloy, H-14 temper.
1. Finish and Thickness: Stucco-embossed finish, 0.016 inch thick.
 2. Moisture Barrier: 1-mil- thick, heat-bonded polyethylene and kraft paper.
 3. Elbows: Preformed, 45- and 90-degree, short- and long-radius elbows; same material, finish, and thickness as jacket.
- F. Stainless-Steel Jacket: Deep corrugated sheets of stainless steel complying with ASTM A 666, Type 304 or 316; 0.10 inch thick; and roll stock ready for shop or field cutting and forming to indicated sizes.
1. Moisture Barrier: 1-mil- thick, heat-bonded polyethylene and kraft paper.
 2. Elbows: Gore type, for 45- and 90-degree elbows in same material, finish, and thickness as jacket.
 3. Jacket Bands: Stainless steel, Type 304, 3/4 inch wide.
- G. Heavy PVC Pipe Fitting Covers: Factory-fabricated fitting covers manufactured from 30-mil-thick, high-impact, ultraviolet-resistant PVC.
1. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories for the disabled.
 2. Adhesive: As recommended by insulation material manufacturer.
- H. Standard PVC Pipe Fitting Covers: Factory-fabricated fitting covers manufactured from 20-mil- thick, high-impact, ultraviolet-resistant PVC.
1. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories for the disabled.
 2. Adhesive: As recommended by insulation material manufacturer.

2.4 REMOVABLE INSULATION COVERS

- A. Pre-manufactured easily removable insulation cover/blanket intended for insulation of equipment and devices requiring periodic maintenance.

2.5 ACCESSORIES AND ATTACHMENTS

- A. Glass Cloth and Tape: Comply with MIL-C-20079H, Type I for cloth and Type II for tape. Woven glass-fiber fabrics, plain weave, presized a minimum of 8 oz. /sq. yd.
1. Tape Width: 4 inches.
- B. Bands: 3/4 inch wide, in one of the following materials compatible with jacket:
1. Stainless Steel: ASTM A 666, Type 304; 0.020 inch thick.
 2. Galvanized Steel: 0.005 inch thick.
 3. Aluminum: 0.007 inch thick.
 4. Brass: 0.010 inch thick.
 5. Nickel-Copper Alloy: 0.005 inch thick.

- C. Wire: 0.080-inch, nickel-copper alloy; 0.062-inch, soft-annealed, stainless steel; or 0.062-inch, soft-annealed, galvanized steel.
- D. Weld-Attached Anchor Pins and Washers: Copper-coated steel pin for capacitor-discharge welding and galvanized speed washer. Pin length sufficient for insulation thickness indicated.
 - 1. Welded Pin Holding Capacity: 100 lb for direct pull perpendicular to the attached surface.
- E. Adhesive-Attached Anchor Pins and Speed Washers: Galvanized steel plate, pin, and washer manufactured for attachment to duct, pipe, plenum and breeching with adhesive. Pin length sufficient for insulation thickness indicated.
 - 1. Adhesive: Recommended by the anchor pin manufacturer as appropriate for surface temperatures of ducts, pipes, plenums, and breechings; and to achieve a holding capacity of 100 lb. for direct pull perpendicular to the adhered surface.
- F. Self-Adhesive Anchor Pins and Speed Washers: Galvanized steel plate, pin, and washer manufactured for attachment to duct, pipe, and plenum with adhesive. Pin length sufficient for insulation thickness indicated.

2.6 VAPOR RETARDERS

- A. Mastics: Materials recommended by insulation material manufacturer that are compatible with insulation materials, jackets, and substrates.

2.7 REMOVABLE INSULATION COVERS

- A. Pre-manufactured easily removable insulation cover/blanket intended for insulation of equipment and devices requiring periodic maintenance.

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.
- B. 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.

3.3 GENERAL APPLICATION REQUIREMENTS

- A. Apply insulation materials, accessories, and finishes according to the manufacturer's written instructions; with smooth, straight, and even surfaces; and free of voids throughout the length of piping, and fittings.
- B. Refer to schedules at the end of this Section for materials, forms, jackets, and thickness required for each system.

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- C. Use accessories compatible with insulation materials and suitable for the service. Use accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Apply multiple layers of insulation with seams staggered.
- E. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- F. Seal joints and seams with vapor-retarder mastic on insulation indicated to receive a vapor retarder.
- G. Keep insulation materials dry at all times. Insulation that becomes wet or is otherwise damaged beyond repair shall be removed immediately and replaced. Replacement material and installation shall be in accordance with these specifications.
- H. Apply insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by the insulation material manufacturer.
- I. Apply insulation with the minimum number of joints practical.
- J. Apply insulation over fittings, valves, and specialties, with continuous thermal and vapor-retarder integrity, unless otherwise indicated.
- K. Refer to special instructions for applying insulation over fittings, valves, and specialties.
- L. Hangers and Anchors: Where vapor retarder is indicated, seal penetrations in insulation at hangers, supports, anchors, and other projections with vapor-retarder mastic.
 - 1. Apply insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor retarders are indicated, extend insulation on anchor legs at least 12 inches from point of attachment to pipe and taper insulation ends. Seal tapered ends with a compound recommended by the insulation material manufacturer to maintain vapor retarder.
 - 3. Install insert materials and apply insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by the insulation material manufacturer.
 - 4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect the jacket from tear or puncture by the hanger, support, and shield.
- M. Insulation Terminations: For insulation application where vapor retarders are indicated, seal ends with a compound recommended by the insulation material manufacturer to maintain vapor retarder.
- N. Apply insulation with integral jackets as follows:
 - 1. Pull jacket tight and smooth.
 - 2. Joints and Seams: Cover with tape and vapor retarder as recommended by insulation material manufacturer to maintain vapor seal.
 - 3. Vapor-Retarder Mastics: Where vapor retarders are indicated, apply mastic on seams and joints and at ends adjacent to pipe joints and fittings.
- O. Cut insulation according to manufacturer's written instructions to prevent compressing insulation to less than 75 percent of its nominal thickness.
- P. Install vapor-retarder mastic on pipes and equipment.

1. Pipes and equipment with vapor retarders: Overlap insulation facing at seams and seal with vapor-retarder mastic and pressure-sensitive tape having same facing as insulation. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-retarder seal.
 2. Pipes and equipment without vapor retarders: Overlap insulation facing at seams and secure with outward clinching staples and pressure-sensitive tape having same facing as insulation.
- Q. Roof Penetrations: Apply insulation for interior applications to a point even with top of roof flashing.
1. Seal penetrations with vapor-retarder mastic.
 2. Apply insulation for exterior applications tightly joined to interior insulation ends.
 3. Seal insulation to roof flashing with vapor-retarder mastic.
- R. Interior Wall and Partition Penetrations: Apply insulation continuously through walls and partitions, except fire-rated walls and partitions.
- S. Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire/smoke damper sleeves for fire-rated wall and partition penetrations.
- T. Floor Penetrations: Terminate insulation at underside of floor assembly and at floor support at top of floor.
1. For insulation indicated to have vapor retarders, taper termination and seal insulation ends with vapor-retarder mastic.

3.4 MINERAL-FIBER INSULATION APPLICATION

- A. Blanket Applications for Pipes: Secure blanket insulation with adhesive, and anchor pins with speed washers.
1. Apply adhesives according to manufacturer's recommended coverage rates per square foot, for 100 percent coverage of pipe surfaces.
 2. Apply adhesive to entire circumference of pipes and to all surfaces of fittings and transitions.
 3. Install anchor pins and speed washers on sides, top, and bottom of horizontal pipes.
 4. Impale insulation over anchors and attach speed washers.
 5. Cut excess portion of pins extending beyond speed washers. Cover exposed pins and washers with tape matching insulation facing.
 6. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation segment with 1/2-inch staples, 1-inch o.c., and cover with pressure-sensitive tape having same facing as insulation.
 7. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. Secure with steel band at end joints and spaced a maximum of 18 inches o.c.
 8. Apply insulation on pipe fittings and transitions with a full insulation segment for each surface. Apply insulation on pipe elbows with individually mitered gores cut to fit the elbow.
 9. Insulate pipe hangers and flanges that protrude beyond the insulation surface with 6-inch-wide strips of the same material as insulation. Secure on alternating sides of stiffener, hanger, and flange with anchor pins spaced 6 inches o.c.

10. Apply vapor-retarder mastic to open joints, breaks, and punctures for insulation indicated to receive vapor retarder.

B. Board Applications for Equipment: Secure board insulation with adhesive and anchor pins and speed washers.

1. Apply adhesives according to manufacturer's recommended coverage rates per square foot, for 100 percent coverage of duct, plenum, & equipment surfaces.
2. Apply adhesive to all surfaces of fittings and equipment.
3. Cut excess portion of pins extending beyond speed washers. Cover exposed pins and washers with tape matching insulation facing.
4. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation segment with 1/2-inch staples, 1-inch o.c., and cover with pressure-sensitive tape having same facing as insulation.
5. Insulate equipment stiffeners, hangers, and flanges that protrude beyond the insulation surface with 6" wide strips of the insulating material. Secure on alternating sides of stiffener, hanger, and flange with anchor pins spaced 6 inches o.c.
6. Apply vapor-retarder mastic to open joints, breaks, and punctures for insulation indicated to receive vapor retarder.

3.5 FLEXIBLE ELASTOMERIC THERMAL INSULATION APPLICATION

A. Apply insulation to ducts, plenums, and equipment as follows:

1. Follow the manufacturer's written instructions for applying insulation.
2. Seal longitudinal seams and end joints with manufacturer's recommended adhesive. Cement to avoid openings in insulation that will allow passage of air to the duct, plenum, and equipment surface.

3.6 CLOSED-CELL PHENOLIC-FOAM INSULATION APPLICATION

A. Apply insulation as follows:

1. Secure each layer of insulation with stainless-steel bands at 12-inch intervals and tighten without deforming the insulation materials.
2. Apply two-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with 0.062-inch, soft-annealed, stainless steel wire spaced at 12-inch intervals. Secure outer layer with stainless-steel bands at 12-inch intervals.
3. On exposed applications, finish insulation with a skim coat of mineral-fiber, hydraulic-setting cement to surface of installed insulation. When dry, apply flood coat of lagging adhesive and press on one layer of glass cloth or tape. Overlap edges at least 1 inch. Apply finish coat of lagging adhesive over glass cloth or tape. Thin the finish coat to achieve smooth finish.

3.7 FIELD-APPLIED JACKET APPLICATION

A. Apply glass-cloth jacket, where indicated, directly over bare insulation or insulation with factory-applied jackets.

1. Apply jacket smooth and tight to surface with 2-inch overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch-thick coats of jacket manufacturer's recommended adhesive.

3. Completely encapsulate insulation with jacket, leaving no exposed raw insulation.

3.8 FINISHES

- A. Glass-Cloth Jacketed Insulation: Paint insulation finished with glass-cloth jacket as indicated.
- B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.
- C. Color: Final color shall be as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

3.9 APPLICATIONS

- A. Insulation materials and thickness are specified at the end of this Section.
- B. Insulate all pipe and equipment:
 1. Insulate pipe in accordance with the application schedule(s) below.
 2. Exceptions: Unless otherwise indicated, do not apply insulation to the following systems, materials, and equipment:
 - a. Vibration-control devices.
 - b. Testing agency labels and stamps.
 - c. Nameplates and data plates.
 - d. Manholes.
 - e. Handholes.
 - f. Cleanouts.
 - g. Plastic Condensate Drain piping.
 - h. Factory-insulated equipment.
 - i. Flexible connectors.

3.10 INDOOR APPLICATION SCHEDULE (ABOVE GRADE):

- A. Service: Domestic hot water and domestic circulated hot water.
 1. Insulation Material: Mineral fiber preformed or flexible elastomeric pipe insulation.
 2. Insulation Thickness: Apply the following insulation thicknesses:
 - a. Copper Pipe, ½" through 1½" in diameter: 1"
 - b. Copper Pipe, 1½" through 3" in diameter: 1 ½"
 - c. Copper Pipe, larger than 3" in diameter: 2"
 3. Vapor Retarder Required: No.
 4. Finish: Exposed = Painted, concealed = none.
- B. Service: Domestic cold water.
 1. Insulation Material: Mineral fiber preformed or flexible elastomeric pipe insulation.
 2. Insulation Thickness: ½"
 3. Vapor Retarder Required: Yes.
 4. Finish: Exposed = Painted, concealed = none.
- C. Service: Rainwater conductors (Including secondary roof drain conductors). Insulate first thirty linear feet of piping including vertical piping from drain body and first horizontal piping run. If a second vertical run occurs before thirty linear feet is reached, terminate insulation at end of first horizontal run.

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1. Insulation Material: Mineral fiber preformed pipe insulation or Mineral-Fiber Blanket with Factory Applied FSK Jacket.
 2. Insulation Thickness: 1"
 3. Vapor Retarder Required: Yes.
 4. Finish: Exposed = Painted, concealed = none.
- D. Service: Roof drain and overflow drain bodies.
1. Insulation Material: Semi-Rigid Mineral-Fiber Board Thermal Insulation
 2. Insulation Thickness: 1½"
 3. Vapor Retarder Required: Yes.
 4. Finish: Exposed = Painted, concealed = none.
- E. Service: Exposed piping:
1. Mineral fiber preformed pipe insulation with Factory Applied FSK Jacket.
 2. Insulation Thickness: 1"
 3. Vapor Retarder Required: Yes.
 4. Finish: Exposed = Painted, concealed = none.
- F. Service: Floor Drains, Traps, and Sanitary Drain Piping within 10 Feet of Drain Receiving Drainage from any Equipment. Measurement shall be pipe length.
1. Insulation Material: Mineral fiber preformed pipe insulation with Factory Applied FSK Jacket.
 2. Insulation Thickness: 1"
 3. Vapor Retarder Required: Yes.
 4. Finish: Exposed = Painted, concealed = none.
- G. Service: Condensate Drains, & Traps.
1. Insulation Material: Mineral fiber preformed pipe insulation with Factory Applied FSK Jacket.
 2. Insulation Thickness: 1"
 3. Vapor Retarder Required: Yes.
 4. Finish: Exposed = Painted, concealed = none.
- H. Service: Equipment Non-condensate Drains, & Traps.
1. Insulation Material: Mineral fiber preformed pipe insulation with Factory Applied FSK Jacket.
 2. Insulation Thickness: 1"
 3. Vapor Retarder Required: Yes.
 4. Finish: Exposed = Painted, concealed = none.
- 3.11 INDOOR APPLICATION SCHEDULE (BELOW GRADE):
1. None required.

END OF SECTION 220700

SECTION 221113 – FACILITY NATURAL-GAS PIPING

1.1 RELATED DOCUMENTS

- A. Provisions of the Contract and of the Contract Documents apply to this Section.

1.2 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, 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.

1.3 PERFORMANCE REQUIREMENTS

- A. Minimum Operating-Pressure Ratings:
 - 1. Piping and Valves: 100 psig minimum unless otherwise indicated.
 - 2. Service Regulators: 65 psig minimum unless otherwise indicated.
 - 3. Service Meter: 65 psig minimum unless otherwise indicated.
- B. Gas System Pressures: Primary pressure from the utility is more than 2.0 psig and is reduced to a secondary pressure of 2.0 psig by a pressure reducing valve installed immediately downstream of the meter and is reduced again by pressure reducing valves located at each piece of equipment.

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. Service meters. Indicate pressure ratings and capacities. Include bypass fittings bypass fittings and meter bars meter bars.
 - 6. Dielectric fittings.
- B. Operation and Maintenance Data: For motorized gas valves, pressure regulators, and service meters to include in operation and maintenance manuals.

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1.5 QUALITY ASSURANCE

- A. Electrical Components and Devices: If indicated, provide electrical components and devices that are listed and labeled as defined in NFPA 70, Article 100, by testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Applicable Codes: Comply with the Virginia Uniform Statewide Building Code and the International Fuel Gas Code.
- C. Fuel Gas Piping: Listed and labeled as required by the International Fuel Gas Code.
- D. UL Standard: Provide components listed in UL's "Gas and Oil Equipment Directory" where UL listing is indicated.
- E. Steel Support Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- F. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Handling Flammable Liquids: Remove and dispose of liquids from 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: Contract with utility-locating service for area where Project is located and locate utilities.
- B. Design values of fuel gas supplied for these systems are as follows:
 - 1. Nominal Heating Value: 1000 Btu/cu.ft.
 - 2. Nominal Specific Gravity: 0.6.
- C. Interruption of Natural-Gas Service: Do not interrupt natural-gas service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide purging and startup of natural-gas supply according to requirements indicated:

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1. Notify Owner and Architect no fewer than two days in advance of proposed interruption of natural-gas service.
2. Do not proceed with interruption of natural-gas service without Owner and Architect's written permission.

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.
- C. Coordinate with equipment and regulator manufacturer's recommendations and local utility service provider for final regulator and accessory selections.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

- A. Refer to Part 3 "Piping Applications" Article for applications of pipe, tube, fitting, and joining materials.

2.2 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.

2.3 PROTECTIVE COATING

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- A. Furnish pipe and fittings with factory-applied, corrosion-resistant polyethylene coating for use in corrosive atmosphere.

2.4 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.

2.5 VALVES

- A. Refer to section "General Duty Valves for Plumbing Piping".

2.6 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
 - 6. End Fittings: Zinc-coated steel.
 - 7. Threaded Ends: Comply with ASME B1.20.1.
 - 8. Maximum Length: 72"
- B. 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 2" and smaller; flanged ends for 2 1/2" and larger.
 - 3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
 - 4. CWP Rating: 125 psig.
- C. 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.

2.7 SPECIALTY VALVES

- A. Available Manufacturers:
 - 1. ASCO General Controls.
 - 2. Automatic Switch Co.
 - 3. Eaton Corp.; Controls Div.
 - 4. Honeywell, Inc.
 - 5. Johnson Controls, Inc.

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- B. Automatic Gas Valves: ANSI Z21.21, with **[electrical]** **[mechanical]** operator for actuation by appliance automatic shutoff device.

- 2.8 Valves, 2" and Smaller: Ball valves with threaded ends according to ASME B1.20.1 for pipe threads.

- 2.9 Valves, 2-1/2" and Larger: Butterfly valves for use with flanged ends according to ASME B16.5 for steel flanges.

- 2.10 PRESSURE REGULATORS
 - A. Available Manufacturers:
 - 1. Line Pressure Regulators:
 - a. American Meter Co.
 - b. Donkin: Bryan Donkin RMG Canada, Ltd.
 - c. Eclipse Combustion, Inc.
 - d. Equimeter, Inc.
 - e. Fisher Controls International, Inc.
 - f. Maxitrol Co.
 - g. National Meter.
 - h. Richards Industries, Inc.; Jordan Valve Div.
 - i. Schlumberger Industries; Gas Div.

 - B. Description: Single stage and suitable for fuel gas service. Include steel jacket and corrosion-resistant components, elevation compensator, and atmospheric vent.
 - 1. 2" and Smaller: Threaded ends according to ASME B1.20.1 for pipe threads.
 - 2. 2 1/2" and Larger: Flanged ends according to ASME B16.5 for steel flanges and according to ASME B16.24 for copper and copper-alloy flanges.
 - 3. Line Pressure Regulators: ANSI Z21.80 with 5-psig- minimum inlet pressure rating.
 - 4. Appliance Pressure Regulators: ANSI Z21.18 with 2-psig minimum inlet pressure. Regulator may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction. If vents are required provided piping necessary to extend to termination location outside the building as approved by the architect.

 - C. Pressure Regulator Vents: Factory- or field-installed, corrosion-resistant screen in opening if not connected to vent piping. Extend to exterior of building and terminate in location approved by the architect.

 - D. Appliance Pressure Regulators: Comply with ANSI Z21.18.
 - 1. Available Manufacturers:
 - a. Canadian Meter Company Inc.
 - b. Eaton Corporation; Controls Div.
 - c. Harper Wyman Co.
 - d. Maxitrol Company.

- e. SCP, Inc.
- 2. Body and Diaphragm Case: Die-cast aluminum.
- 3. Springs: Zinc-plated steel; interchangeable.
- 4. Diaphragm Plate: Zinc-plated steel.
- 5. Seat Disc: Nitrile rubber.
- 6. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
- 7. Factory-Applied Finish: Minimum three-layer polyester and polyurethane paint finish.
- 8. Regulator may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction.
- 9. Maximum Inlet Pressure: 2 psig.

2.11 CONCRETE BASES

- A. Description: Reinforced concrete base formed of 3000-psi- minimum, 28-day compressive strength concrete, and measuring 6 inches thick and 6 inches larger in each dimension than equipment, unless otherwise indicated.

2.12 DIELECTRIC FITTINGS

A. Dielectric Unions:

- 1. Available Manufacturers:
 - a. Capitol Manufacturing Company.
 - b. Central Plastics Company.
 - c. Hart Industries International, Inc.
 - d. McDonald, A. Y. Mfg. Co.
 - e. Watts Regulator Co.; Division of Watts Water Technologies, Inc.
 - f. Wilkins; Zurn Plumbing Products Group.
 - g. Conbraco Industries-Apollo
- 2. Minimum Operating-Pressure Rating: 150 psig.
- 3. Combination fitting of copper alloy and ferrous materials.
- 4. Insulating materials suitable for natural gas.
- 5. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.

B. Dielectric Flanges:

- 1. Available Manufacturers:
 - a. Capitol Manufacturing Company.
 - b. Central Plastics Company.
 - c. Watts Regulator Co.; Division of Watts Water Technologies, Inc.
 - d. Wilkins; Zurn Plumbing Products Group.
- 2. Minimum Operating-Pressure Rating: 150 psig.
- 3. Combination fitting of copper alloy and ferrous materials.
- 4. Insulating materials suitable for natural gas.
- 5. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.

C. Dielectric-Flange Kits:

1. Available Manufacturers:
 - a. Advance Products & Systems, Inc.
 - b. Calpico Inc.
 - c. Central Plastics Company.
 - d. Pipeline Seal and Insulator, Inc.
2. Minimum Operating-Pressure Rating: 150 psig.
3. Companion-flange assembly for field assembly.
4. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or PE bolt sleeves, phenolic washers, and steel backing washers.
5. Insulating materials suitable for natural gas.
6. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.

2.13 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 wide and 4 mils 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 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. Close equipment shutoff valves before turning off fuel gas to premises or piping section.
- B. Inspect natural-gas piping according to the International Fuel Gas Code to determine that natural-gas utilization devices are turned off in piping section affected.
- C. Comply with the International Fuel Gas Code requirements for prevention of accidental ignition.

3.3 SERVICE ENTRANCE PIPING

- A. Extend fuel gas piping and connect to fuel gas distribution piping downstream of meter.

1. Service meter will be provided by Local Gas Utility.

B. Install dielectric fitting downstream from and adjacent to each service meter unless meter is supported from service-meter bar with integral dielectric fitting. Install shutoff valve downstream from and adjacent to dielectric fitting. Refer to Division 22 Section "Common Work Results for Plumbing" for dielectric fittings.

C. [Install strainer upstream from each earthquake valve.]

3.4 CONCRETE BASE INSTALLATION

A. Locate bases at service meters and service regulators.

B. Excavate earth and make level beds to support bases. Form and pour concrete bases level with top surface projecting approximately 3 inches above grade.

3.5 OUTDOOR PIPING INSTALLATION

A. Comply with the International Fuel Gas Code for installation and purging of natural-gas piping.

B. Install underground, natural-gas piping buried at least 36 inches below finished grade. Comply with requirements in Section "Earth Moving" for excavating, trenching, and backfilling.

1. If natural-gas piping is installed less than 36 inches below finished grade, install it in containment conduit.

C. Install underground, PE, natural-gas piping according to ASTM D 2774.

D. Steel Piping 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.

E. Copper Tubing Protective Coating:

1. Apply joint cover kits over tubing to cover, seal, and protect joints.
2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.

F. Install fittings for changes in direction and branch connections.

G. Install pressure gage upstream and downstream from each service regulator. Pressure gages are specified in Section "Meters and Gages for Plumbing Piping."

3.6 INDOOR PIPING INSTALLATION

A. Comply with the International Fuel Gas Code for installation and purging of natural-gas piping.

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- 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 be accepted by architect.
- 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.
- E. Install piping indicated to be exposed and piping in equipment rooms 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 toward drip and sediment traps.
- I. Install piping free of sags and bends.
- J. Install fittings for changes in direction and branch connections.
- K. Verify final equipment locations for roughing-in.
- L. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.
- M. 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 long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.
- N. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.
- O. 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.
- P. 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.

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2. In Floors: Install pre-sleeved corrugated, stainless-steel tubing systems for natural-gas. Cover with minimum of 1-1/2 inches of concrete. Jacket may not be in physical contact with metallic structures such as reinforcing rods or electrically neutral conductors. Do not embed piping in concrete slabs containing quick-set additives.
 3. 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.
 4. 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.
- Q. Connect branch piping from top or side of horizontal piping.
- R. Install unions in pipes 2" and smaller, adjacent to each valve, at final connection to each piece of equipment and where otherwise indicated. Unions are not required at flanged connections.
- S. Do not use natural-gas piping as grounding electrode.
- T. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.
- U. Install pressure gage upstream and downstream from each line regulator. Pressure gages are specified in Section "Meters and Gages for Plumbing Piping."
- V. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section "Sleeves and Sleeve Seals for Plumbing Piping."
- W. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section "Sleeves and Sleeve Seals for HVAC Piping."
- X. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 22 Section "Escutcheons for Plumbing Piping."
- Y. Install corrugated, stainless-steel tubing system according to manufacturer's written instructions. Include striker plates to protect tubing from puncture where tubing is restrained and cannot move.
- Z. Install containment casings for gas piping below slabs extending minimum of 2 inches beyond point where pipe emerges from the floor. Tightly seal ends around gas piping using mechanical sleeve seals.
- 3.7 SERVICE-METER ASSEMBLY INSTALLATION
- A. Provide concrete base for service meter.

- B. Install locking shutoff valves downstream from service regulator. Shutoff valves are not required at second regulator if two regulators are installed in series.
- C. Install strainer on inlet of service-pressure regulator.
- D. Install service pressure regulator mounted outside with vent outlet horizontal or facing down. Install screen in vent outlet if not integral with service regulator.
- E. Install metal shutoff valves upstream from service meters. Install dielectric fittings downstream from service meters.

3.8 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.

3.9 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.
- E. Flanged Joints: Install gasket material, size, type, and thickness appropriate for natural-gas service. Install gasket concentrically positioned.

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- F. Flared Joints: Cut tubing with roll cutting tool. Flare tube end with tool to result in flare dimensions complying with SAE J513. Tighten finger tight, then use wrench. Do not overtighten.
- G. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.
 - 1. Plain-End Pipe and Fittings: Use butt fusion.
 - 2. Plain-End Pipe and Socket Fittings: Use socket fusion.

3.10 HANGER AND SUPPORT INSTALLATION

- A. Comply with requirements for pipe hangers and supports specified in Section "Hangers and Supports for Plumbing Piping and Equipment."
- B. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:
 - 1. 1" and Smaller: Maximum span, 96"; minimum rod size, 3/8".
 - 2. 1 1/4": Maximum span, 108"; minimum rod size, 3/8".
 - 3. 1 1/2" and 2": Maximum span, 108"; minimum rod size, 3/8".
 - 4. 2 1/2" to 3 1/2": Maximum span, 10'-0"; minimum rod size, 1/2".
 - 5. 4" and Larger: Maximum span, 10'-0"; minimum rod size, 5/8".
- C. Install hangers for horizontal, corrugated stainless-steel tubing with the following maximum spacing and minimum rod sizes:
 - 1. 3/8": Maximum span, 48"; minimum rod size, 3/8".
 - 2. 1/2": Maximum span, 72"; minimum rod size, 3/8".
 - 3. 3/4" and Larger: Maximum span, 96"; minimum rod size, 3/8".

3.11 CONNECTIONS

- A. Connect to utility's gas meter according to utility's procedures and requirements.
- B. Install piping adjacent to appliances to allow service and maintenance of appliances.
- C. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72" of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.
- D. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

3.12 PIPING APPLICATIONS

- A. Flanges, unions, transition, and special fittings with pressure ratings same as or higher than system pressure rating may be used in applications below, unless otherwise indicated.

B. Above Ground Exposed Fuel Gas Piping:

1. Sizes up to 2":
 - a. Steel pipe, malleable-iron threaded fittings, and threaded joints.
2. 2½" to 4":
 - a. Steel pipe, malleable-iron threaded fittings, and threaded joints, or steel pipe, steel welding fittings, and welded joints.
3. Larger Than NPS 4:
 - a. Steel pipe, steel welding fittings, and welded joints.

C. Above Ground Concealed Fuel Gas Piping:

1. Sizes up to 2":
 - a. Steel pipe, malleable-iron threaded fittings, and threaded joints.
2. 2½" to 4":
 - a. Steel pipe, malleable-iron threaded fittings, and threaded joints, or steel pipe, steel welding fittings, and welded joints.
3. Larger Than NPS 4:
 - a. Steel pipe, steel welding fittings, and welded joints.

D. Exterior Underground Fuel Gas Piping:

1. All Sizes: Polyethylene pipe, fittings and joining materials.

E. Under Slab Fuel Gas Piping: (NOTICE: Method of fuel gas piping installation below floor slab must be approved by the local code authority.)

1. Pre-Sleeved Corrugated, Stainless-Steel Tubing Systems.
2. Steel pipe, steel welding fittings, and welded joints with welded steel vented conduit.

3.13 LABELING AND IDENTIFYING

- A. Comply with requirements in Section "Identification for Plumbing Piping and Equipment" for piping and valve identification.
- B. Install detectable warning tape directly above gas piping, 12" minimum below finished grade.
 1. Exception: 6 minimum below sub-grade under pavements and slabs.

3.14 PAINTING

- A. Use materials and procedures in Division 9 Section "Painting," "Exterior Paint Schedule" Article, "Ferrous Metal" Paragraph, "Full-Gloss, Alkyd-Enamel Finish" Subparagraph.
- B. Paint exterior service meters, pressure regulators, specialty valves, piping, and accessories.
 1. Color: Gray

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- C. Paint interior exposed service meters, pressure regulators, specialty valves, piping, and accessories.
 - 1. Color: Gray.

3.15 FIELD QUALITY CONTROL

- A. Inspect, test, and purge piping according to ANSI Z223.1, Part 4 "Inspection, Testing, and Purging," and requirements of authorities having jurisdiction.
- B. Repair leaks and defects with new materials and retest system until satisfactory results are obtained.
- C. Report test results promptly and in writing to Architect and authorities having jurisdiction.
- D. Verify capacities and pressure ratings of service meters, pressure regulators, valves, and specialties.
- E. Verify correct pressure settings for pressure regulators.
- F. Verify that specified piping tests are complete.

3.16 ADJUSTING

- A. Adjust controls and safety devices. Replace damaged and malfunctioning controls and safety devices.

END OF SECTION 221113

SECTION 221116 –DOMESTIC WATER 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 PERFORMANCE REQUIREMENTS

- A. Provide components and installation capable of producing domestic water piping systems with the following minimum working-pressure ratings, unless otherwise indicated:
 - 1. Domestic Water Service Piping: 160 psig.
 - 2. Domestic Water Distribution Piping: 125 psig.
- B. Seismic Performance: Refer to structural drawings for seismic category. Domestic water piping, support, and installation shall withstand the effects of earthquake motions determined in accordance with ASCE/SEI 7, state, and local codes.

1.3 SUBMITTALS

- A. Product Data: For pipe, tube, fittings, and couplings.
- B. Water Samples: Specified in “Cleaning” Article.
- C. Coordination Drawings: For piping in equipment rooms and other congested areas, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:
 - 1. Fire-suppression-water piping.
 - 2. Domestic water piping.
 - 3. Compressed air piping.
 - 4. HVAC hydronic piping.
- D. Field quality-control reports.

1.4 QUALITY ASSURANCE

- A. Piping materials shall bear label, stamp, or other markings of specified testing agency.
- B. NSF/ANSI Compliance:
 - 1. NSF/ANSI 61, "Drinking Water System Components – Health Effects"
 - 2. NSF/ANSI 372, "Drinking Water System Components – Lead Content"

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1.5 PROJECT CONDITIONS

- A. Interruption of Existing Water Service: Do not interrupt water service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water service according to requirements indicated:
1. Notify Architect, Construction Manager, Owner no fewer than two days in advance of proposed interruption of water service.
 2. Do not proceed with interruption of water service without Architect's, Construction Manager's, Owner's written permission.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

- A. 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.

2.2 COPPER TUBE AND FITTINGS

- A. Hard Copper Tube: ASTM B 88, Type L (ASTM B 88M, Type B) water tube, drawn temper.
1. Cast-Copper Solder-Joint Fittings: ASME B16.18, pressure fittings.
 2. Wrought-Copper Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.
 3. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.
 4. 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.
 5. Copper Pressure-Seal-Joint Fittings:
 - 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) Conex Banninger
 - 2) Elkhart Products Corporation; Industrial Division.
 - 3) Mueller Industries
 - 4) NIBCO INC.
 - 5) Viega; Plumbing and Heating Systems.
 - b. NPS 2 (DN 50) and Smaller: Wrought-copper fitting with EPDM-rubber O-ring seal in each end.
 - c. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Cast-bronze or wrought-copper fitting with EPDM-rubber O-ring seal in each end.
 6. Copper Push-on-Joint Fittings:
 - 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:

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- 1) NVent LLC.
- b. Description: Cast-copper fitting complying with ASME B16.18 or wrought-copper fitting complying with ASME B 16.22; with stainless-steel teeth and EPDM-rubber O-ring seal in each end instead of solder-joint ends.
7. Copper-Tube Extruded-Tee Connections:
 - a. Manufacturers: Subject to compliance with requirements, [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - 1) T-DRILL Industries Inc.
 - b. Description: Tee formed in copper tube according to ASTM F 2014.
8. Grooved-Joint Copper-Tube Appurtenances:
 - a. Manufacturers: Subject to compliance with requirements, [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - 1) Anvil International.
 - 2) Shurjoint Piping Products.
 - 3) Victaulic Company.
 - b. Copper Grooved-End Fittings: ASTM B 75 (ASTM B 75M) copper tube or ASTM B 584 bronze castings.
 - c. Grooved-End-Tube Couplings: Copper-tube dimensions and design similar to AWWA C606. Include ferrous housing sections, EPDM-rubber gaskets suitable for hot and cold water, and bolts and nuts.
- B. Soft Copper Tube: ASTM B 88, Type K (ASTM B 88M, Type A) water tube, annealed temper.
 1. Copper Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.
 2. Copper Pressure-Seal-Joint Fittings:
 - a. Manufacturers: Subject to compliance with requirements, [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - 1) Conex Banninger
 - 2) Elkhart Products Corporation; Industrial Division.
 - 3) Mueller Industries
 - 4) NIBCO INC.
 - 5) Viega; Plumbing and Heating Systems.
 - b. NPS 2 (DN 50) and Smaller: Wrought-copper fitting with EPDM-rubber O-ring seal in each end.
 - c. NPS 3 and NPS 4 (DN 80 and DN 100): Cast-bronze or wrought-copper fitting with EPDM-rubber O-ring seal in each end.

2.3 PIPING JOINING MATERIALS

- A. 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.
- B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.
- C. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
- D. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.

PART 3 - EXECUTION

3.1 EXCAVATION

- A. Refer to other sections for excavating, trenching, and backfilling.

3.2 PIPING APPLICATIONS

- 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 may be used on aboveground piping, unless otherwise indicated.
- C. Grooved joints may be used on aboveground grooved-end piping.
- D. Fitting Options:
 - 1. Mechanically formed tee-branch outlets (T-Drill) and brazed joints may be used on aboveground copper tubing.
 - 2. Press Fittings: Mechanically crimped fittings with neoprene gasket.
- E. Underground Domestic Water Service Piping: Match civil materials to first flange.
- F. Aboveground Domestic Water Piping: Use the following piping materials for each size range:
 - 1. 2" and Smaller:
 - a. Hard copper tube, Type L copper pressure fittings; and soldered joints.
 - 2. 2-1/2" and above":
 - a. Hard copper tube, Type L copper pressure fittings; and soldered joints.
 - b. Hard copper tube, Type L with grooved ends; copper grooved-end fittings; copper-tubing, keyed couplings; and grooved joints.
- G. Underground Domestic Water Piping: Use the following piping materials for each size range:

1. 2" and Smaller:
 - a. Soft copper tube, Type K copper pressure fittings; and soldered joints with no joints permitted below concrete slabs.
2. 2-1/2" and above:
 - a. Soft copper tube, Type K copper pressure fittings; and soldered joints.

3.3 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 bronze ball valves for piping NPS 2 and smaller. Use cast-iron butterfly valves with flanged ends for piping NPS 2-1/2 and larger.
 2. Throttling Duty: Use bronze ball valves for piping NPS 2 and smaller. Use cast-iron butterfly valves with flanged ends for piping NPS 2-1/2 and larger.
 3. Hot-Water-Piping, Balancing Duty: Use automatic flow control valves.
 4. Drain Duty: Hose-end drain valves.
- B. Grooved-end valves may be used with grooved-end piping.

3.4 PIPING INSTALLATION

- A. Extend domestic water service piping to exterior water distribution piping in sizes and locations indicated.
- B. Install underground ductile-iron piping according to AWWA C600, and AWWA M41. Install buried piping inside building between wall and floor penetrations and connection to water service piping outside building with restrained joints. Anchor pipe to wall or floor. Install thrust-block supports at vertical and horizontal offsets.
 1. Encase piping with polyethylene film according to ASTM A 674 or AWWA C105.
- C. Install underground copper according to CDA's "Copper Tube Handbook."
- D. Install cast-iron sleeve with water stop and mechanical sleeve seal at each service pipe penetration through foundation wall. Select number of interlocking rubber links required to make installation watertight.
- E. Install water-pressure regulators downstream from shutoff valves.
- F. Install aboveground domestic water piping level and plumb.
- G. Fill water piping. Check components to determine that they are not air bound and that piping is full of water.
- H. Perform the following steps before operation:
 1. Close drain valves, hydrants, and hose bibbs.
 2. Open shutoff valves to fully open position.

3. Open throttling valves to proper setting.
 4. Remove plugs used during testing of piping and plugs used for temporary sealing of piping during installation.
 5. Remove and clean strainer screens. Close drain valves and replace drain plugs.
 6. Remove filter cartridges from housings, and verify that cartridges are as specified for application where used and that cartridges are clean and ready for use.
- I. Check plumbing equipment and verify proper settings, adjustments, and operation. Do not operate water heaters before filling with water.
 - J. Check plumbing specialties and verify proper settings, adjustments, and operation.
 1. Water-Pressure Regulators: Set outlet pressure at 80 psig maximum, unless otherwise indicated.
 - K. Energize pumps and verify proper operation.

3.5 JOINT CONSTRUCTION

- A. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder; and ASTM B 828 procedure, unless otherwise indicated.
- B. Grooved Joints: Assemble joints with keyed-coupling housing, gasket, lubricant, and bolts according to coupling and fitting manufacturer's written instructions.
- C. Mechanically Formed Outlets: Form tee in copper tube according to equipment manufacturer's written instructions. Use tool designed for copper tube; drill pilot hole, form collar for outlet, dimple tube to form seating stop, and braze branch tube into collar.
- D. Mechanically crimped fittings shall be installed in accordance with manufacturer's installation instructions and by factory accredited installer.

3.6 VALVE INSTALLATION

- A. Install sectional valve close to water main on each branch and riser serving plumbing fixtures or equipment. Use ball valves for piping NPS 2 and smaller. Use butterfly valves for piping NPS 2-1/2 and larger.
- B. Install shutoff valve on each water supply to equipment and on each water supply to plumbing fixtures without supply stops. Use ball valves for piping NPS 2 and smaller. Use butterfly valves for piping NPS 2-1/2 and larger.
- C. Install balancing valve in each hot-water circulation return branch and discharge side of each pump and circulator. Use ball valves for piping NPS 2 and smaller and butterfly valves for piping NPS 2-1/2 and larger.

3.7 HANGER AND SUPPORT INSTALLATION

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- A. Refer to Section 220529 "Hangers and Supports for Plumbing Piping" for pipe hanger and support devices.
- B. 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. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
 - c. Longer Than 100 Feet, if indicated: MSS Type 49, spring cushion rolls.
 - 3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
 - 4. Base of Vertical Piping: MSS Type 52, spring hangers.
- C. Support vertical piping and tubing at base and at each floor.
- D. Rod diameter may be reduced 1 size for double-rod hangers, to a minimum of 3/8 inch.
- E. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 3/4 and Smaller: 60 inches with 3/8-inch rod.
 - 2. NPS 1 and NPS 1-1/4: 72 inches with 3/8-inch rod.
 - 3. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
 - 4. NPS 2-1/2: 108 inches with 1/2-inch rod.
 - 5. NPS 3 to NPS 5: 10 feet with 1/2-inch rod.
 - 6. NPS 6: 10 feet with 5/8-inch rod.
 - 7. NPS 8: 10 feet with 3/4-inch rod.
- F. Where hangers for piping are to be suspended from open-web steel joists, install hangers at maximum spacing that will result in hanger loads that comply with the requirements on the structural drawings.
- G. Install supports for vertical copper tubing every 10 feet.
- H. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.
- I. Where bends in the pipe occur, place hangers 1/3 of the maximum allowed spacing distance of the bend (i.e. is the maximum span is 12 feet, the hanger shall be 4 feet from the bend. Pipe shall be supported from both sides of the bend.

3.8 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.

3.9 FIELD QUALITY CONTROL

- A. Inspect domestic water piping as follows:
 - 1. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.
 - 2. 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:
 - 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 for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
 - 3. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.
 - 4. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
- B. Test domestic water piping as follows:
 - 1. 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 separate report for each test, complete with diagram of portion of piping tested.
 - 2. Leave uncovered and unconcealed new, altered, extended, or replaced domestic water piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
 - 3. Cap and subject piping to static water pressure of 50 psig above operating pressure, 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.
 - 4. Repair leaks and defects with new materials and retest piping or portion thereof until satisfactory results are obtained.
 - 5. Prepare reports for tests and required corrective action.

3.10 ADJUSTING

- A. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow.
 - 1. Manually adjust ball-type balancing valves in hot-water-circulation return piping to provide flow of hot water in each branch.

3.11 CLEANING

- A. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

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- B. Clean and disinfect potable domestic water piping as follows:
1. Purge new piping and parts of existing domestic water piping that have been altered, extended, or repaired before using.
 2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction or, if methods are not prescribed, procedures described in AWWA C651, AWWA C652 or as described below:
 - a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
 - b. Fill and isolate system according to either of the following:
 - 1) Fill system or part thereof with water/chlorine solution with at least 50 ppm of chlorine. Isolate with valves and allow to stand for 24 hours.
 - 2) Fill system or part thereof with water/chlorine solution with at least 200 ppm of chlorine. Isolate and allow to stand for three hours.
 - c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.
 - d. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.
- C. Prepare and submit reports of purging and disinfecting activities to authorities having jurisdiction.

END OF SECTION 221116

SECTION 221119 - DOMESTIC WATER PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Provisions of the Contract and of the Contract Documents apply to this Section.

1.2 PERFORMANCE REQUIREMENTS

- A. Minimum Working Pressure for Domestic Water Piping Specialties: 125 psig, unless otherwise indicated.

1.3 SUBMITTALS

- A. Product Data: For each type of product proposed.
- B. Shop Drawings: Diagram power, signal, and control wiring.
- C. Operation and Maintenance Data: For domestic water piping specialties to include in emergency, operation, and maintenance manuals.

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. NSF Compliance:
 - 1. Comply with NSF 61, "Drinking Water System Components – Health Effects"
 - 2. Comply with NSF 372, "Drinking Water System Components – Lead Content"
 - 3. Comply with NSF 14, "Plastic Piping System Components and Related Materials"
- C. Water Management Installation:
 - 1. Installer Qualifications: An installer who is authorized by the equipment manufacturer for both installation and maintenance of submitted equipment.
 - 2. Provide documentation demonstrating previous experience and successfully completing projects of similar size and scope.
 - 3. Provide a list of installations that the Installer has specifically installed for verification by the Owner. Similar installations from other vendors and/or Installers shall be accepted. The Installer's employees must meet these qualifications.
 - 4. The Installer shall demonstrate to the satisfaction of the Architect/Engineer that he has:
 - a. Adequate plant and equipment to pursue the work properly and expeditiously.
 - b. Adequate staff and technical experience to implement the work.

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- c. Suitable financial status to meet the obligations of the work.
 - d. Technical capable and factory trained service personnel at a local service facility to provide routine and emergency service for all products used in this project.
5. A contractor intending to bid on this work, not meeting the requirements of this section, may employ the services of an "Installer" meeting the requirements of this section. A "subcontractor" so employed must be acceptable to the Architect. The "Installer" shall be identified by submittal for acceptance by the Architect.

PART 2 - PRODUCTS

2.1 VACUUM BREAKERS

A. Pipe-Applied, Atmospheric-Type (Anti-siphon) Vacuum Breakers:

1. Available Manufacturers:
 - a. Ames Co.
 - b. Apollo Valves - Conbraco Industries, Inc.
 - c. Watts Industries, Inc.; Water Products Div.
 - d. Zurn Plumbing Products Group; Wilkins Div.
2. Standard: ASSE 1001.
3. Sizes: ¾" thru 3" as required to match connected piping.
4. Body: Brass or Bronze.
5. Inlet and Outlet Connections: Threaded.
6. Finish: Rough bronze or chrome plated.

B. Pressure Vacuum Breakers:

1. Available Manufacturers:
 - a. Ames Co.
 - b. Apollo Valves - Conbraco Industries, Inc.
 - c. Watts Industries, Inc.; Water Products Div.
 - d. Zurn Plumbing Products Group; Wilkins Div.
2. Standard: ASSE 1020.
3. Operation: Continuous-pressure applications.
4. Accessories:
 - a. Valves: Ball type, on inlet and outlet.

C. Spill-Resistant Vacuum Breakers:

1. Available Manufacturers:
 - a. Apollo Valves - Conbraco Industries, Inc.
 - b. Watts Industries, Inc.; Water Products Div.
2. Standard: ASSE 1056.
3. Operation: Continuous-pressure applications.

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4. Sizes: ¾" thru 1" as required to match connected piping.
5. Accessories:
 - a. Valves: Ball type, on inlet and outlet.

2.2 DISHWASHER AIR-GAP FITTINGS

- A. Description: ASSE 1021, fitting suitable for use with domestic dishwashers and for deck mounting; with plastic body, chrome-plated brass cover; and capacity of at least 5 gpm; and inlet pressure of at least 5 psig at temperature of at least 140 deg F. Include 5/8-inch- ID inlet and 7/8-inch- ID outlet hose connections.
- B. Hoses: Rubber and suitable for temperature of at least 140 deg F.
 1. Inlet Hose: 5/8-inch- ID and 48 inches long.
 2. Outlet Hose: 7/8-inch- ID and 48 inches long.

2.3 BACKFLOW PREVENTERS

- A. Reduced-Pressure-Zone (RPZ) Backflow Preventers:
 1. Available Manufacturers:
 - a. Ames Co.
 - b. Apollo Valves - Apollo Valves - Conbraco Industries, Inc.
 - c. Watts Industries, Inc.; Water Products Div.
 - d. Zurn Plumbing Products Group; Wilkins Div.
 2. Standard: ASSE 1013.
 3. Operation: Continuous-pressure applications.
 4. Pressure Loss: 10 psig maximum, through middle 1/3 of flow range.
 5. Sizes: ¾" thru 10"
 6. Body: Brass or bronze for 2" and smaller; cast iron or steel with interior lining complying with AWWA C550 or that is FDA approved for 2 ½" and larger.
 7. Configuration: Comply with drawing requirements.
 8. Accessories:
 - a. Valves: Ball type with threaded ends on inlet and outlet of 2" and smaller; outside screw and yoke gate-type with flanged ends on inlet and outlet of 2 ½" and larger.
 - b. Air-Gap Fitting: ASME A112.1.2, matching backflow-preventer connection.

2.4 CALIBRATED BALANCING VALVES

- A. Available Manufacturers:
 1. NIBCO
 2. Armstrong Pumps, Inc.
 3. Flow Design, Inc.
 4. Griswold Controls.

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5. ITT Bell & Gossett; ITT Fluid Technology Corp.
6. Nexus Valve.
7. NuTech Hydronic Specialty Products
8. Taco, Inc.

- B. NPS 2 and Smaller: Bronze body, ball type, 125-psig working pressure, 250 deg F maximum operating temperature, and having threaded ends. Valves shall have calibrated orifice or venturi, connections for portable differential pressure meter with integral seals, and be equipped with a memory stop to retain set position.
- C. NPS 2-1/2 and Larger: Cast-iron or steel body, ball type, 125-psig working pressure, 250 deg F maximum operating temperature, and having flanged connections. Valves shall have calibrated orifice or venturi, connections for portable differential pressure meter with integral seals, and be equipped with a memory stop to retain set position.

2.5 TEMPERATURE-ACTUATED WATER MIXING VALVES

A. Thermostatic Master Mixing Valves:

1. Refer to drawing schedule for manufacturer and operating requirements.
2. Available Manufacturers:
 - a. Lawler Manufacturing Company, Inc.
 - b. Leonard Valve Company.
 - c. Powers; a Watts Industries Co.
 - d. Symmons Industries, Inc.
3. Standard: ASSE 1017.
4. Pressure Rating: 125 psig.
5. Material: Bronze body with corrosion-resistant interior components.
6. Connections: union inlets and outlet.
7. Accessories:
 - a. Check stops on hot- and cold-water supplies.
 - b. Handle.
 - c. Dial thermometer on inlets and outlet.
 - d. Pressure gauges on inlets and outlet.
8. Pressure Rating: 125 psig, unless otherwise indicated.

B. Individual-Fixture, Water Tempering Valves:

1. Refer to drawing schedule for manufacturer and operating requirements.
2. Available Manufacturers:
 - a. Apollo Valves - Conbraco Industries, Inc.
 - b. Lawler Manufacturing Company, Inc.
 - c. Leonard Valve Company.
 - d. Powers; a Watts Industries Co.
 - e. Watts Industries, Inc.; Water Products Div.
 - f. Zurn Plumbing Products Group; Wilkins Div.

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3. Standard: ASSE 1070, thermostatically controlled water tempering valve.
4. Pressure Rating: 125 psig minimum, unless otherwise indicated.
5. Body: Bronze body with corrosion-resistant interior components.
6. Temperature Control: Adjustable.
7. Inlets and Outlet: Threaded. Provide unions and valves.
8. Finish: Chrome-plated bronze.

2.6 STRAINERS

A. Pattern: "Y"

1. Pressure Rating: 125 psig minimum, unless otherwise indicated.
2. Body: Bronze for NPS 2 and smaller; cast iron or steel with interior lining complying with AWWA C550 or FDA-approved, epoxy coating and for NPS 2-1/2 and larger.
3. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
4. Screen: Stainless steel with round perforations, unless otherwise indicated.
5. Perforation Size:
 - a. Strainers NPS 2 and Smaller: 0.033 inch.
 - b. Strainers NPS 2-1/2 to NPS 4: 0.062 inch.
 - c. Strainers NPS 5 and Larger: 0.10 inch.
6. Drain: Factory-installed, hose-end drain valve.

2.7 WATER HAMMER ARRESTERS

A. Available Manufacturers:

1. AMTROL, Inc.
 2. Josam Company.
 3. MIFAB, Inc.
 4. PPP Inc.
 5. Sioux Chief Manufacturing Company, Inc.
 6. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 7. Tyler Pipe; Wade Div.
 8. Watts Drainage Products Inc.
 9. Zurn Plumbing Products Group; Specification Drainage Operation.
- B. Standard: ASSE 1010 or PDI-WH 201.
- C. Type: Metal bellows or copper tube with piston.
- D. Size: ASSE 1010, Sizes AA and A through F or PDI-WH 201, Sizes A through F.

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2.8 TRAP-SEAL PRIMER VALVES

A. Supply-Type, Trap-Seal Primer Valves:

1. Available Manufacturers:

- a. MIFAB, Inc.
- b. PPP Inc.
- c. Sioux Chief Manufacturing Company, Inc.
- d. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
- e. Watts Industries, Inc.; Water Products Div.

2. Standard: ASSE 1018.

3. Pressure Rating: 125 psig minimum.

4. Body: Bronze.

5. Inlet and Outlet Connections: NPS 1/2 threaded, union, or solder joint.

6. Gravity Drain Outlet Connection: NPS 1/2 threaded or solder joint.

7. Finish: Chrome plated, or rough bronze for units used with pipe or tube that is not chrome finished.

B. Drainage-Type, Trap-Seal Primer Valves:

1. Available Manufacturers:

- a. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.

2. Standard: ASSE 1044, lavatory P-trap with NPS 3/8 minimum, trap makeup connection.

3. Size: NPS 1-1/4 minimum.

4. Material: Chrome-plated, cast brass.

2.9 TRAP-SEAL PRIMER SYSTEMS

A. Trap-Seal Primer Systems:

1. Available Manufacturers:

2. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

- a. PPP Inc.

3. Standard: ASSE 1044

4. Piping: ASTM B 88, Type L; copper, water tubing.

5. Cabinet: Unless otherwise indicated, recessed or surface-mounting steel box with stainless-steel cover.

6. Electric Controls: 24-hour timer, solenoid valve, and manual switch for 120-V ac power.

7. Vacuum Breaker: ASSE 1001.

8. Number of Outlets: Refer to drawings.

9. Size of Outlets: 1/2"

2.10 HOSE BIBBS

- A. Refer to plumbing fixture rough-in schedule on drawings.

2.11 WALL HYDRANTS

- A. Refer to plumbing fixture rough-in schedule on drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Refer to Section "Common Work Results for Plumbing" for piping joining materials, joint construction, and basic installation requirements.
- B. Install backflow preventers where indicated: If not indicated on 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 balancing valves with-in 12" of ceiling at access door or tile where they can be reached with-out obstruction.
- D. Install thermostatic mixing valves with check stops or shutoff valves on inlets and with shutoff valve on outlet.
 - 1. Install thermometers and pressure gauges.
 - 2. Install cabinet-type units recessed in or surface mounted on wall as indicated.
- E. Install strainers where indicated.
- F. Install outlet boxes recessed in wall. Install 2-by-4-inch fire-retardant-treated-wood blocking wall reinforcement between studs. Fire-retardant-treated-wood blocking is specified in Section "Rough Carpentry."
- G. Install supply-type, trap-seal primer valves with outlet piping pitched down toward drain trap a minimum of 1/8" per foot, and connect to floor-drain body, trap, or inlet fitting. Adjust valve for proper flow.

- H. Install drainage-type, trap-seal primer valves as lavatory trap with outlet piping pitched down toward drain trap a minimum of 1/8" per foot, and connect to floor-drain body, trap, or inlet fitting.
- I. Install trap-seal primer systems with outlet piping pitched down toward drain trap a minimum of 1/8" per foot, and connect to floor-drain body, trap, or inlet fitting. Adjust system for proper flow.
- J. Install trap guards in accordance with manufacturer's instructions.
- K. Fasten wall-hanging plumbing specialties securely to supports attached to building substrate if supports are specified and to building wall construction if no support is indicated.
- L. Fasten recessed-type plumbing specialties to reinforcement built into walls.
- M. Install wood-blocking reinforcement for wall-mounting and recessed-type plumbing specialties.
- N. Install individual shutoff valve in each water supply to plumbing specialties. Use ball valve if specific valve is not indicated. Install shutoff valves in accessible locations. Refer to Section "Valves" for general-duty ball valves.
- O. Install air vents at water piping high points. Include ball valve in inlet.
- P. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.
- Q. 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.
- R. Specific trap primer assembly and primer pipe routing not always indicated on plans to provide contractor field flexibility in selecting option best suitable for field conditions, where alternative options may be acceptable. Contractor shall coordinate and provide any necessary items to facilitate proper installation and operation of the preferred and approved primer system; to include, but not limited to, electrical conduit and circuitry to the panelboard for electronic systems.

3.2 LABELING AND IDENTIFYING

- A. Indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Section "Plumbing Identification"

3.3 FIELD QUALITY CONTROL

- A. Perform the following tests and prepare test reports:

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1. Test each reduced-pressure-principal backflow preventer, double-check backflow-preventer and double-check, detector-assembly according to authorities having jurisdiction and the device manufacturer's recommendations.

B. Remove and replace malfunctioning domestic water piping specialties and retest as specified above.

3.4 ADJUSTING

A. Set field-adjustable pressure set points.

B. Set field-adjustable flow set points.

C. Set field-adjustable temperature set points.

END OF SECTION 221119

SECTION 221316 - SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Provisions of the Contract and of the Contract Documents apply to this Section.

1.2 DEFINITIONS

- A. The following are industry abbreviations for plastic and rubber piping materials:
 - 1. EPDM: Ethylene-propylene-diene terpolymer.
 - 2. LEED: Leadership in Energy and Environmental Design
 - 3. NBR: Acrylonitrile-butadiene rubber.
 - 4. PE: Polyethylene plastic.
 - 5. PVC: Polyvinyl chloride plastic.
 - 6. TPE: Thermoplastic elastomer.
 - 7. USGBC: United States Green Building Council

1.3 PERFORMANCE REQUIREMENTS

- A. Provide components and installation capable of producing piping systems with the following minimum working-pressure ratings, unless otherwise indicated:
 - 1. Soil, Waste, and Vent Piping: 10-foot head of water.

1.4 SUBMITTALS

- A. Product Data: For pipe, tube, fittings, and couplings.
- B. Submittal:
 - 1. Product Data for USGBC LEED Credit EQ 4.1: For solvent cements and adhesive primers, include printed statement of VOC content.

1.5 QUALITY ASSURANCE

- A. Piping materials shall bear label, stamp, or other markings of testing agency.
- B. Cast iron soil pipe shall be clearly marked with the manufacturer's name, county of origin, eight-digit date code, pipe diameter and length, relevant ASTM standard and registered trademark of third part certifier.

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1. Third party certifier shall be IAPMO, ICC, NSF, or other organization that is accredited as an ANSI – Guide 65 organization. Reference www.ansi.org.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

- A. Refer to Part 3 "Piping Applications" Article for applications of pipe, tube, fitting, and joining materials.
- B. Flexible Transition Couplings for Underground Non-Pressure Piping: ASTM C 1173 with elastomeric sleeve. Include ends of same sizes as piping to be joined and include corrosion-resistant metal band on each end.

2.2 CAST-IRON SOIL PIPING

- A. Pipe and Fittings: ASTM A 888 or CISPI 301.
- B. Hub-and-Spigot Gaskets: ASTM C 564, rubber.
- C. Hub-less Couplings:
 1. All hub-less couplings shall bear the NSF trademark.
 2. General: CISPI 310 and ASTM C 1277 assembly of stainless steel corrugated shield, stainless steel bands and fasteners, and ASTM C 564 rubber sleeve with integral, center pipe stop.
 - 1) Heavy-Duty, Type 304, Stainless-Steel Couplings: ASTM C 1540, Type 304, stainless-steel shield; stainless-steel bands; and ASTM C 564, rubber sleeve.
 - a) NPS 1-1/2 to NPS 4: 3-inch- wide shield with 4 bands.
 - b) NPS 5 to NPS 10: 4-inch- wide shield with 6 bands.
 - b. Heavy-Duty, Cast-Iron Couplings: ASTM A 48/A 48M, 2-piece, cast-iron housing; stainless-steel bolts and nuts; and ASTM C 564, rubber sleeve.
- D. Manufacturers:
 1. AB&I Foundry
 2. Charlotte Pipe & Foundry Co.
 3. Tyler Pipe & Coupling

2.3 PVC PIPE AND FITTINGS

- A. Solid-Wall PVC Pipe: ASTM D 2665, drain, waste, and vent.

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1. PVC Socket Fittings: ASTM D 2665, socket type, made to ASTM D 3311, drain, waste, and vent patterns.

B. Solvent Cement and Adhesive Primer:

1. Use PVC solvent cement that has a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.4 COPPER TUBE AND FITTINGS

- A. Copper DWV Tube: ASTM B 306, drainage tube, drawn temper.
- B. Copper Drainage Fittings: ASME B16.23, cast copper or ASME B16.29, wrought copper, solder-joint fittings.
- C. Solder: ASTM B 32, lead free with ASTM B 813, water-flushable flux.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

- A. Transition fittings with pressure ratings at least equal to piping pressure ratings may be used in applications below, unless otherwise indicated.
- B. Aboveground, Soil, Waste, and Vent Piping located inside plenum: Hub-less cast-iron soil piping with heavy duty couplings.
- C. Aboveground, Soil, Waste, and Vent Piping located outside plenum: PVC pipe, PVC socket fittings, and solvent-cemented joints.
- D. Underground, Soil, Waste, and Vent Piping:
 1. Kitchen Waste: Extra Heavy Hub and Spigot cast-iron soil piping.
 2. Other than kitchen waste: PVC pipe and fittings.
 3. Other than kitchen waste: Service Weight Hub and Spigot cast iron soil pipe and fittings.

3.2 PIPING INSTALLATION

- A. Refer to Section "Facility Sanitary Sewers" for Project-site sanitary sewer piping.
- B. Refer to Section "Common Work Results for Plumbing" for basic installation.

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- C. Install seismic restraints on piping when indicated. Seismic-restraint devices are not required in zones A & B. Seismic-restraint devices are specified in Section "Vibration and Seismic Controls for Plumbing Piping and Equipment".
- D. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers.
- E. Install cleanout fitting with closure plug inside the building in sanitary force-main piping.
- F. Install seismic restraints on piping when indicated. Seismic-restraint devices are specified in Section "Vibration and Seismic Controls for Plumbing Piping and Equipment."
- G. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers.
- H. Install cast-iron sleeve with water stop and mechanical sleeve seal at each service pipe penetration through foundation wall. Select number of interlocking rubber links required to make installation watertight.
- I. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."
- J. 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 drainpipe. 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.
- K. 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.
- L. Install soil and waste drainage and vent piping at the minimum slopes required by authorities having jurisdiction.
- M. Install PVC soil and waste drainage and vent piping according to ASTM D 2665.
- N. Install underground PVC soil and waste drainage piping according to ASTM D 2321.
- O. Install aboveground copper tubing according to CDA's "Copper Tube Handbook."
- P. Install all drainage pattern fittings and piping in accordance with all applicable federal, state, and local codes.

- Q. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.
- R. Sleeves are not required for cast-iron soil piping passing through concrete slabs-on-grade if slab is without membrane waterproofing.
- S. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section "Sleeves and Sleeve Seals for Plumbing Piping."
- T. Install sleeve seals for piping penetrations of concrete and masonry walls and slabs. Comply with requirements for sleeve seals specified in Section "Sleeves and Sleeve Seals for Plumbing Piping."
- U. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section "Escutcheons for Plumbing Piping"

3.3 JOINT CONSTRUCTION

- A. Refer to section "Common Work Results for Plumbing" for basic piping joint construction.
- B. Join hub-and-spigot, cast-iron soil piping with gasket joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.
- C. Join hub-less cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hub-less-coupling joints.
- D. PVC Non-pressure Piping Joints: Join piping according to ASTM D 2665.
- E. Join copper tube and fittings with soldered joints according to ASTM B 828. Use ASTM B 813, water-flushable, lead-free flux and ASTM B 32, lead-free-alloy solder.

3.4 HANGER AND SUPPORT INSTALLATION

- A. Refer to Section "Vibration and Seismic Controls for Plumbing Piping and Equipment" for seismic-restraint devices in zones other than A & B.
- B. Join hubless cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-coupling joints.
- C. 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. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.

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- c. Longer Than 100 Feet, if indicated: MSS Type 49, spring cushion rolls.
- 3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
- 4. Base of Vertical Piping: MSS Type 52, spring hangers.
- D. Support vertical piping and tubing at base and at each floor.
- E. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch minimum rods.
- F. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
 - 1. 1 1/2" and 2": 60" with 3/8"rod.
 - 2. 3": 60" with 1/2"rod.
 - 3. 4" and NPS 5: 60" with 5/8" rod.
 - 4. 6": 60" with 3/4" rod.
 - 5. 8" to 12": 60" with 7/8" rod.
 - 6. 15": 60" with 1" rod.
- G. Install supports for vertical cast-iron soil piping every 15 feet.
- H. Install hangers for PVC piping with the following maximum horizontal spacing and minimum rod diameters:
 - 1. 1 1/2" and 2": 48" with 3/8" rod.
 - 2. 3": 48" with 1/2" rod.
 - 3. 4" and 5": 48" with 5/8" rod.
 - 4. 6": 48" with 3/4" rod.
 - 5. 8" to 12": 48" with 7/8" rod.
- I. Install supports for vertical PVC piping every 48".
- J. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.5 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.
- C. Connect drainage and vent piping.

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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: Where required or indicated prepare inspection reports and have them signed by authorities having jurisdiction.
- D. Test sanitary drainage and vent piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
 - 1. 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 separate report for each test, complete with diagram of portion of piping tested.
 - 2. Leave uncovered and unconcealed new, altered, extended, or replaced drainage and vent piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
 - 3. Roughing-in Plumbing Test Procedure: Test drainage and vent piping, except outside leaders, on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.
 - 4. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
 - 5. 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.

3.8 PROTECTION

- A. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

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- B. Exposed PVC Piping: Protect plumbing vents exposed to sunlight with two coats of water-based latex paint.

END OF SECTION 221316

SECTION 221319 - SANITARY WASTE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Provisions of the Contract and of the Contract Documents apply to this Section.

1.2 ABBREVIATIONS

- A. RPZ Reduced Pressure Zone
- B. FOG Fats, oils, and greases.

1.3 DEFINITIONS

- A. Withstand: Units shall remain in place without separation of any parts when subjected to seismic forces indicated. "Essential facility" units shall be fully operational after the seismic event.
- B. Operation and Maintenance Data: To include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

- A. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.
- B. Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic sanitary piping specialty components.

1.5 COORDINATION

- A. Coordinate size and location of roof penetrations.
- B. Coordinate accessories, extensions, collars, flashing clamps, etc... for field conditions and installation requirements for roof assemblies and other construction assemblies to provide final and proper compliant installation.

PART 2 - PRODUCTS

2.1 CLEANOUTS

A. General:

1. Available Manufacturers:
 - 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
2. Standard: ASME A112.36.2M.
3. Size: Same as connected drainage piping
4. Closure Material: Match pipe, brass, PVC, or ABS

B. Floor Cleanouts:

1. Housing: threaded, adjustable.
2. Type: Threaded, adjustable housing.
3. Body: Cast iron.
4. Outlet Connection: Inside calk, Spigot, or Threaded.
5. Adjustable Housing Material: Cast iron with threads.
6. Frame and Cover Material and Finish: Satin finish nikaloy.
7. Frame and Cover Shape: Round or Square (Contractors Option).
8. Top Loading Classification: Extra Heavy Duty.
9. Riser: ASTM A 74, Service weight, cast-iron drainage pipe fitting and riser to cleanout.
10. Carpet Ring: Yes for carpeted floors.
11. Tile Recess: Yes for tiled floors.
12. Terrazzo: Yes for terrazzo floors

C. Wall Cleanouts:

1. Wall access: Yes
2. Body: Match connected piping.
3. Closure: Countersunk or raised-head, drilled-and-threaded plug.
4. Closure Plug Size: Same as cleanout size but not larger than four inches in diameter.
5. Wall Access: Round, flat, chrome-plated brass, nickel-bronze, copper-alloy, or stainless-steel cover plate with screw.

2.2 FLOOR DRAINS

1. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 - a. Josam Company; Josam Div.
 - b. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - c. Tyler Pipe; Wade Div.

- d. Watts Drainage Products Inc.
 - e. Zurn Plumbing Products Group; Light Commercial Operation.
 - f. Zurn Plumbing Products Group; Specification Drainage Operation.
- 2. Standard: ASME A112.6.3
 - 3. Pattern: As indicated.
 - 4. Clamping Flange: Required.

2.3 THROUGH-PENETRATION FIRESTOP ASSEMBLIES

A. Through-Penetration Firestop Assemblies:

- 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. ProSet Systems Inc.
- 2. Standard: UL 1479 assembly of sleeve and stack fitting with firestopping plug.
- 3. Size: Same as connected soil, waste, or vent stack.
- 4. Sleeve: Molded PVC plastic, of length to match slab thickness and with integral nailing flange on one end for installation in cast-in-place concrete slabs.
- 5. Plastic Stack Fitting (For Use Where Plastic Stacks Are Indicated): ASTM A 48/A 48M, gray-iron, hubless-pattern, wye branch with neoprene O-ring at base and gray-iron plug in thermal-release harness. Include PVC protective cap for plug.
- 6. Special Coating (For Use Where Plastic Laboratory Stacks are Indicated): Corrosion resistant on interior of fittings.

2.4 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

A. Floor-Drain, Trap-Seal Primer Fittings:

- 1. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 - a. PPP
 - b. Josam
 - c. Smith
 - d. Zurn
- 2. Description: Cast iron, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection.
- 3. Size: Same as floor drain inlet.

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.

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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.

2.5 MOTORS

- A. General requirements for motors are specified in Division 22 Section "Common Motor Requirements for Plumbing Equipment."
 1. 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.
 2. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 26 Sections.

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.
- C. Install cleanout deck plates with top flush with finished floor.
- D. For wall cleanouts located in concealed piping, install cleanout access covers, with cover tight to 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 as indicated. If indication is not clear, position for easy access and maintenance.
 2. Set floor drains at elevations indicated.
 3. Install floor-drain flashing flange so no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes where penetrated.
 4. Install individual traps for floor drains connected to sanitary building drain.
- F. Install through-penetration firestop assemblies in plastic conductors and stacks at rated penetrations.
- G. Install floor-drain, trap-seal primer fittings on inlet to floor drains indicated to receive trap-seal primer.
- H. Install air-gap fittings on RPZ backflow preventers and where indicated.

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- I. Install sleeve flashing device with each riser and stack passing through floors with waterproof membrane.

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.
- 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 LABELING AND IDENTIFYING

- A. Distinguish among multiple units, inform operator of operational requirements, and refer to Division 22 Section "Identification for Plumbing Piping and Equipment."

3.4 FIELD QUALITY CONTROL

- A. Checks and Inspections:
 - 1. Leak Check: After installation, charge system and check for leaks. Repair leaks and recheck until no leaks exist.

3.5 PROTECTION

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

END OF SECTION 221319

SECTION 224000 - PLUMBING FIXTURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Provisions of the Contract and of the Contract Documents apply to this Section.

1.2 DEFINITIONS

- A. ABS: Acrylonitrile-butadiene-styrene plastic.
- B. FRP: Fiberglass-reinforced plastic.
- C. PMMA: Polymethyl methacrylate (acrylic) plastic.
- D. PVC: Polyvinyl chloride plastic.
- E. RFI: Request for information.
- F. Accessible Fixture: Plumbing fixture that can be approached, entered, and used by people with disabilities.
- G. Cast Polymer: Cast-filled-polymer-plastic material. This material includes cultured-marble and solid-surface materials.
- H. Cultured Marble: Cast-filled-polymer-plastic material with surface coating.
- I. Fitting: Device that controls flow of water into or out of plumbing fixture. Fittings specified in this Section include supplies and stops, faucets and spouts, showerheads and tub spouts, drains and tailpieces, and traps and waste pipes.
- J. Solid Surface: Nonporous, homogeneous, cast-polymer-plastic material with heat-, impact-, scratch-, and stain-resistance qualities.
- K. Other Manufacturers: Use one of those listed.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, finishes, and security anchors for security plumbing fixtures.
 - 2. Include rated capacities, operating characteristics, and furnished specialties and accessories.
- B. Performance Submittals:
 - 1. Product Data:
 - a. Documentation indicating flow and water consumption requirements.
 - b. WaterSense labeling for all applicable and eligible fixtures and accessories.

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1.4 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For security plumbing fixtures and components to include in maintenance manuals.
- B. Faucet Cartridges, washers, aerators and O-Rings: Equal to five percent (5%) of amount of each type and size installed but not less than five (5) of each type and size.
- C. Flushometer Valve Repair Kits: Equal to ten percent (10%) of quantity of each type installed, or six (6), whichever is less.
- D. Provide Minimum number of key operators (wrenches/tools) for loose key stops, wall hydrants, aerators, security fasteners and any fixture where a key, security fastener, or special tool is required:
 - 1. One (1) for ten percent (10%) of each size or ten (10), whichever is less.

1.5 QUALITY ASSURANCE

- A. Source Limitations: Obtain plumbing fixtures, faucets, and other components of each category through one source from a single manufacturer.
 - 1. Exception: If fixtures, faucets, or other components are not available from a single manufacturer, obtain similar products from other manufacturers specified for that category.
- B. Electrical Components, Devices, and Accessories: Electrical components, devices, and accessories shall be 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. 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. Comply with requirements in Public Law 102-486, "Energy Policy Act," regarding 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. EPA WaterSense: Provide fixtures with WaterSense labeling for all applicable and eligible fixtures and accessories.
- F. Select combinations of fixtures and trim, faucets, fittings, and other components that are compatible.
- G. Comply with the following standards and other requirements where applicable:
 - 1. Enameled, Cast-Iron Fixtures: ASME A112.19.1M.
 - 2. Porcelain-Enameled, Formed-Steel Fixtures: ASME A112.19.4M.
 - 3. Slip-Resistant Bathing Surfaces: ASTM F 462.
 - 4. Solid-Surface-Material Lavatories and Sinks: ANSI/ICPA SS-1.
 - 5. Stainless-Steel Commercial, Handwash Sinks: NSF 2 construction.
 - 6. Stainless-Steel Residential Sinks: ASME A112.19.3.
 - 7. Vitreous-China Fixtures: ASME A112.19.2M.
 - 8. Water-Closet, Flush Valve, Tank Trim: ASME A112.19.5.
 - 9. Water-Closet, Flushometer Tank Trim: ASSE 1037.
 - 10. Whirlpool Bathtub Fittings: ASME A112.19.8M.

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11. Backflow Protection Devices for Faucets with Side Spray: ASME A112.18.3M.
12. Backflow Protection Devices for Faucets with Hose-Thread Outlet: ASME A112.18.3M.
13. Diverter Valves for Faucets with Hose Spray: ASSE 1025.
14. Faucets: ASME A112.18.1.
15. Hose-Connection Vacuum Breakers: ASSE 1011.
16. Hose-Coupling Threads: ASME B1.20.7.
17. Integral, Atmospheric Vacuum Breakers: ASSE 1001.
18. NSF Potable-Water Materials: NSF 61.
19. Pipe Threads: ASME B1.20.1.
20. Sensor-Actuated Faucets and Electrical Devices: UL 1951.
21. Supply Fittings: ASME A112.18.1.
22. Brass Waste Fittings: ASME A112.18.2.
23. Backflow Protection Devices for Hand-Held Showers: ASME A112.18.3M.
24. Combination, Pressure-Equalizing and Thermostatic-Control Antiscald Faucets: ASSE 1016.
25. Deck-Mounted Bath/Shower Transfer Valves: ASME 18.7.
26. Faucets: ASME A112.18.1.
27. Hand-Held Showers: ASSE 1014.
28. High-Temperature-Limit Controls for Thermal-Shock-Preventing Devices: ASTM F 445.
29. Hose-Coupling Threads: ASME B1.20.7.
30. Manual-Control Antiscald Faucets: ASTM F 444.
31. Pipe Threads: ASME B1.20.1.
32. Pressure-Equalizing-Control Antiscald Faucets: ASTM F 444 and ASSE 1016.
33. Sensor-Actuated Faucets and Electrical Devices: UL 1951.
34. Thermostatic-Control Antiscald Faucets: ASTM F 444 and ASSE 1016.
35. Atmospheric Vacuum Breakers: ASSE 1001.
36. Brass and Copper Supplies: ASME A112.18.1.
37. Dishwasher Air-Gap Fittings: ASSE 1021.
38. Manual-Operation Flushometers: ASSE 1037.
39. Plastic Tubular Fittings: ASTM F 409.
40. Brass Waste Fittings: ASME A112.18.2.
41. Sensor-Operation Flushometers: ASSE 1037 and UL 1951.
42. Disposers: ASSE 1008 and UL 430.
43. Dishwasher Air-Gap Fittings: ASSE 1021.
44. Flexible Water Connectors: ASME A112.18.6.
45. Floor Drains: ASME A112.6.3.
46. Grab Bars: ASTM F 446.
47. Hose-Coupling Threads: ASME B1.20.7.
48. Hot-Water Dispensers: ASSE 1023 and UL 499.
49. Off-Floor Fixture Supports: ASME A112.6.1M.
50. Pipe Threads: ASME B1.20.1.
51. Plastic Shower Receptors: ANSI Z124.2.
52. Plastic Toilet Seats: ANSI Z124.5.
53. Supply and Drain Protective Shielding Guards: ICC A117.1.
54. Whirlpool Bathtub Equipment: UL 1795.

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1.6 COORDINATION

- A. Coordinate all accessories. Ensure items fit and work together as an assembly. Provide additional accessories to accommodate final installed field conditions; to include, but not limited to, offsets and other items required for ADA compliance. Provide necessary accessories and components for complete installation.
- B. Coordinate roughing-in and final plumbing fixture locations and verify that fixtures can be installed to comply with design.
- C. Model numbers are intended to identify families of fixtures and may be incomplete. Refer to other contract documents for hand.
- D. Where fixtures or its associated components are installed in rated floors, walls, or ceilings; provide rated fixtures, accessories, and components of equal rating.
- E. Where the flush valve assembly height would conflict with the rear grab bar installation (including the minimum 1-1/2" clearance to the bottom of the grab bar), the vacuum breaker flush tube shall be shortened. Shortening of the vacuum breaker flush tube shall not exceed the manufacturer's requirements for maintaining proper operation, including the CL (critical line) markings on the flush tube if provided by the manufacturer to indicate shortening limitations.

1.7 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. Faucet Cartridges, washers, aerators and O-Rings: Equal to 5 percent of amount of each type and size installed but not less than 5 of each type and size.
 - 2. Flushometer Valve, Repair Kits: 5 of each type.

PART 2 - PRODUCTS

2.1 (**EWC-1**) BI-LEVEL WATER COOLER (ACCESSIBLE) WITH BOTTLE FILLING STATION

- A. Manufacturer & Model Number: Elkay LZSTL8WSSP
 - 1. Self-contained wall hung electric refrigerated water cooler
 - 2. Push bar activation on front, left, & right of unit.
 - 3. Built-in flow regulator
 - 4. Connect to water supply using dielectric coupling.
 - 5. Polyester elastomer flexible bubbler.
 - 6. Provide non-metallic strainer.
 - 7. Provide quick connect fittings.
 - 8. Provide cane apron on upper fountain.
 - 9. Provide bottle filling station on ADA fountain.
 - 10. Material: Stainless steel.
 - 11. Color: Manufacturer's standard.
 - 12. Electrical: 115V, 1 PH, 60 HZ, 5.0 Full load amps, 370 Watts.
- B. Supply: McGuire Part Number 2165-N3-F
 - 1. 1/2" IPS x 3/8" OD

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2. ½" x 3" chrome plated brass nipple.
 3. Heavy brass chrome plated wall flange with set-screw
 4. Provide dielectric connection.
- C. Provide 1½" diameter plastic tailpiece extension. Electrically isolate cooler from drainage and vent system.
- D. Trap: McGuire Part Number 8912-C-F
1. Size: 1-1/2" x 1-1/2"
 2. Material: Polished chrome plated cast brass.
 3. Cleanout plug: Yes
 4. Nuts: Polished chrome plated brass.
 5. Wall bend: 17-gauge seamless tubular chrome plated brass.
 6. Wall flange: Chrome plated brass with setscrew. Where drainpipe connection protrudes from wall contractor may provide deep flange.
- E. Other Manufacturers: Provide products, features, and accessories equal to those specified above.
1. Drinking Fountain:
 - a. Halsey Taylor
 - b. Haws Corp
 - c. Oasis
 2. Trap:
 - a. Kohler
 - b. Cambridge Brass

2.2 **(HB-1)** HOSE BIBB – FLUSH MOUNTED, LOOSE KEY OPERATED

- A. Manufacturer and Model Number: Zurn Z1333XL
1. Vacuum Breaker: Yes (integral).
 2. Outlet: ASME B1.20.7, garden-hose threads.
 3. ¾" Inlet
 4. Ball valve ¼ turn or compression.
 5. Brass Construction.
 6. Loose key operated.
 7. Automatic self-draining.
- B. Available Manufacturers:
1. Josam
 2. T&S
 3. Chicago
 4. Arrowhead Brass

2.3 **(LA-1)** WALL-HUNG LAVATORY (ACCESSIBLE) WITH MANUAL FAUCET

- A. Manufacturer & Model Number: Zurn Z5310
- B. Material: Vitreous China
- C. Color: White

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- D. Faucet: Zurn
 - 1. 4" Spout
 - 2. 0.50 GPM Maximum Flow
 - 3. Chrome plate
 - 4. All Brass Body
 - 5. Renewable Seat and Washers
 - 6. Wrist Blade Handles
- E. Drain: McGuire Part Number 155A
- F. Trap: McGuire Part Number 8902C-F
 - 1. 1-1/4"x 1-1/2" cast brass polished chrome trap with cleanout plug and brass slip nuts.
 - 2. 17-gauge seamless tubular chrome plated brass wall bend.
 - 3. Forged brass chrome plated wall flange with setscrew.
- G. Supplies: McGuire Part Number 2165-N3-F
 - 1. 1/2" IPS x 3/8" OD
 - 2. 1/2" x 3" chrome plated brass nipple.
 - 3. Heavy brass chrome plated wall flange with set-screw
 - 4. Contractor shall coordinate supply connection to faucet.
- H. Insulation: Tru-Bro Lav Guard #102
 - 1. Color: White
 - 2. Insulate P-trap, hot and cold angle valves, hot and cold risers.
- I. Carrier: Josam Series 17100
 - 1. Floor mounted with rectangular uprights.
- J. Other Manufacturers: Provide products, features, and accessories equal to those specified above.
 - 1. Lavatory
 - a. American Standard
 - b. Eljer
 - c. Gerber
 - 2. Faucet:
 - a. Speakman
 - b. Cambridge Brass
 - c. T&S Brass
 - d. Moen
 - 3. Drain:
 - a. Kohler
 - b. Cambridge Brass
 - c. Chicago
 - 4. Trap:
 - a. Kohler
 - b. Cambridge Brass
 - 5. Supplies:
 - a. Cambridge Brass
 - b. Kohler
 - 6. Insulation:
 - a. McGuire

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7. Carrier:
 - a. JR Smith

2.4 **(MB-1)** MOP/SERVICE BASIN

- A. Manufacturer & Model Number: Fiat TSB3001
- B. Shoulders shall not be less than 9" high inside measurement, and not less than 1" wide. The tiling flange shall be cast integral to the unit and shall extend 1" above the shoulder on 2 sides. Basin shall be composed of marble chips and Portland cement ground smooth and sealed to resist stains. A one piece, 20-gauge, type-302 stainless-steel cap shall be integrally cast into the unit on four sides.
 1. Dimensions: 32" x 32" x 12".
 2. Cap: Stainless steel on 4 sides.
 3. Tiling Flange: Yes, on two sides.
 4. Material: Terrazzo
 5. Color: Manufacturer's standard
- C. Faucet: Zurn Z843M4-XL-CS-HCT
 1. 8" center
 2. Vacuum breaker spout
 3. Lever Handles
 4. Integral supply check stops
 5. Pail hook
 6. Wall support
- D. Drain: Cast brass with stainless steel strainer or equal as furnished with sink.
- E. Trap: 3" (Provide additional pipe and material transition as required make connection to sink)
- F. Stainless utility shelf with mop/broom holders and rag hooks: Bobrick Model B-239
- G. Provide the following other Accessories
 1. Hose Hook
 2. 36" long hose
- H. Other Manufacturers: Provide products, features, and accessories equal to those specified above.
 1. Service Sink
 - a. Fiat
 - b. Just
 - c. Florestone
 2. Faucet:
 - a. T&S
 - b. Water Saver
 - c. Royal Brass
 - d. Speakman

2.5 **(SH-1)** INDIVIDUAL TRANSFER SHOWER (ACCESSIBLE)

- A. Manufacturer & Model Number: BestBath 4LSS3838FB5T

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1. Molded 4-piece gelcoat/fiberglass enclosure.
2. Barrier-free 5/8" threshold transfer-shower.
3. White smooth wall finish.
4. Integral wood backing.
5. Stainless steel grab bar.
6. Folding accessible seat.
7. Soap dish.
8. Rubber water stopper.

B. Shower Valve: Zurn Z7301-SS-MT-DV2P-HW-H7-S8

1. Pressure balanced valve
2. Fixed shower head at 1.75gpm.
3. Hand-held shower set with 60" flex hose at 2.00gpm.
4. 30" Slide bar for hand-held shower mounted with stainless steel plates and bolts
5. Diverting valve
6. Integral service check stops

C. Provide one (1) outside white cotton shower curtain and one (1) inside vinyl curtain liner.

D. Provide chrome plated brass curtain rod and flanges.

E. Provide two (2) sets of rollerball type shower curtain hooks.

F. Provide self-sealing brass drain and strainer with membrane clamp.

G. Other Manufacturers: Provide products, features, and accessories equal to those specified above.

1. Shower Enclosure
 - a. Aquabath
 - b. Aquarius
2. Shower Valve
 - a. Leonard
 - b. Bradley

2.6 **(SH-1)** INDIVIDUAL SHOWER (ACCESSIBLE)

A. Manufacturer & Model Number: Resinous coating by architectural.

B. Shower Valve: Zurn Z7301-SS-MT-DV2P-HW-H9-S9

1. Temperature and pressure balanced valve
2. ASSE-1016
3. Fixed shower head
4. Hand held shower set with 60" flex hose
5. 30" Slide bar for hand held shower mounted with stainless steel plates and bolts
6. Diverting valve
7. Integral service check stops

C. Provide one (1) outside white cotton shower curtain and one (1) inside vinyl curtain liner.

D. Provide chrome plated brass curtain rod and flanges.

E. Provide two (2) sets of rollerball type shower curtain hooks.

F. Provide self-sealing brass drain and strainer.

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- G. Other Manufacturers: Provide products, features, and accessories equal to those specified above.
1. Tiled shower enclosure by architectural.
 2. Shower Valve
 - a. Leonard
 - b. Bradley
 - c. Moen
 - d. Symmons

2.7 **(SK-1)** KITCHENETTE SINK (ACCESSIBLE)

- A. Manufacturer & Model Number: Elkay LRADQ-221955
1. Overall Length (left to right): 22"
 2. Overall Width (front to back): 19-1/2"
 3. Inside Bowl Depth: 5-1/2"
 4. Material: 18 Gauge Stainless Steel
 5. Number of Bowls: 1
 6. Drain location: Off-center, rear.
 7. Mounting: Inside hole ratchet system equal to Elkay Quick-Clip® mounting system. Systems requiring access from below shall not be permitted.
 8. Deck Hole drilling configuration:
 - a. 3 holes, 4" apart, centered.
- B. Faucet: Zurn Z82300-XL-CP4-3M
1. Hole configuration: 3 Hole installation, 4" centers.
 2. Spout: 10" arc swing spout.
 3. Handles: Single lever.
 4. Aerator: Vandal resistant, pressure compensating, 0.50 gpm
 5. Cartridges: Ceramic or compression ¼ turn.
 6. Meets ADA requirements: Yes
 7. Other:
 - a. Red & blue temperature indicators. Red = Hot, blue = cold.
- C. Basket Strainer & Tail Piece: McGuire Part Number 151
1. Material: Forged brass, chrome plated.
 2. Tailpiece: 1-1/2" x 4" 20-gauge seamless brass, chrome plated.
 3. Nuts: Cast brass lock, slip, and coupling, chrome plated
- D. Trap: McGuire Part Number 8912-C-F
1. Size: 1-1/2" x 1-1/2"
 2. Material: Polished chrome plated cast brass.
 3. Cleanout plug: Yes
 4. Nuts: Polished chrome plated brass.
 5. Wall bend: 17-gauge seamless tubular chrome plated brass.
 6. Wall flange: Chrome plated brass with setscrew. Where pipe protrudes from wall contractor may provide deep flange.
- E. Supplies: McGuire Part Number 2167-N3-F
1. Inlet: ½" IPS

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2. Outlet: ½" OD compression.
 3. Nipple: ½" x 3" chrome plated brass.
 4. Wall flange: Heavy brass chrome plated with set-screw.
- F. Insulation: Tru-Bro Lav Guard #102
1. Insulate P-trap, hot and cold angle valves, hot and cold risers.
- G. Other Manufacturers: Provide products, features, and accessories equal to those specified above.
1. Sink
 - a. Kohler
 - b. Just
 - c. Eagle Group
 2. Faucet:
 - a. Speakman
 - b. Cambridge Brass
 - c. T&S Brass
 - d. Moen
 3. Basket Strainer & Tail Piece:
 - a. Kohler
 - b. Cambridge Brass
 4. Trap:
 - a. Kohler
 - b. Cambridge Brass
 5. Supplies:
 - a. Chicago
 - b. Cambridge Brass
 - c. T&S

2.8 **(SK-2)** 3-COMPARTMENT ART SINK WITH DRAIN BOARDS

- A. Manufacturer & Model Number: Elkay Sturdibilt SS8372LR
1. Overall Length (left to right): 120"
 2. Overall Width (front to back): 27-1/2"
 3. Inside Bowl Depth: 14"
 4. Mounting: Free standing with integral legs and secured to wall to limit movement.
 5. Number of Bowls: 3
 6. Drain location: Center of each bowl.
 7. Drain boards on both left and right sides.
 8. 8" Backsplash
 9. 36" Height to rim.
 10. Deck Hole drilling configuration:
 - a. 2 Sets of 2 holes, 4" apart, each centered between bowls.
- B. Faucet(s): (2) Zurn Z812H2-XL-TWM-3F
1. Hole configuration: 2 Holes installation, 4" centers. Mount off center each.
 2. Spout: 12" long swing spout.
 3. Handles: Levers.
 4. Aerator: Vandal resistant, pressure compensating, 0.50 gpm
 5. Cartridges: Ceramic or compression ¼ turn.

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6. Meets ADA requirements: Yes
7. Other:
 - a. Red & blue temperature indicators. Red = Hot, blue = cold.
- C. Basket Strainers & Tail Pieces: (3) McGuire Part Number 151
 1. Material: Forged brass, chrome plated.
 2. Tailpiece: 2" x 4" 20-gauge seamless brass, chrome plated.
 3. Nuts: Cast brass lock, slip, and coupling, chrome plated
- D. Trap: McGuire Part Number 8912-C-F
 1. Size: 2" x 2"
 2. Material: Polished chrome plated cast brass.
 3. Cleanout plug: Yes
 4. Nuts: Polished chrome plated brass.
 5. Wall bend: 17-gauge seamless tubular chrome plated brass.
 6. Wall flange: Chrome plated brass with setscrew. Where pipe protrudes from wall contractor may provide deep flange.
- E. Supplies: (2 sets) McGuire Part Number 2167-N3-F
 1. Inlet: 1/2" IPS
 2. Outlet: 1/2" OD compression.
 3. Nipple: 1/2" x 3" chrome plated brass.
 4. Wall flange: Heavy brass chrome plated with set-screw.
- F. Accessories: Provide unions, valves, and fittings required for complete installation.
- G. Other Manufacturers: Provide products, features, and accessories equal to those specified above.
 1. Sink
 - a. Kohler
 - b. Just
 - c. Eagle Group
 2. Faucet:
 - a. Chicago
 - b. T&S
 - c. Speakman
 - d. Moen
 3. Basket Strainer & Tail Piece:
 - a. Kohler
 - b. Cambridge Brass
 4. Trap:
 - a. Kohler
 - b. Cambridge Brass
 5. Supplies:
 - a. Chicago
 - b. Cambridge Brass
 - c. T&S

2.9 **(SK-3)** ART AND MUSIC SINK (ACCESSIBLE)

- A. Manufacturer & Model Number: Elkay LRADQ-221955

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1. Overall Length (left to right): 22"
 2. Overall Width (front to back): 19-1/2"
 3. Inside Bowl Depth: 5-1/2"
 4. Material: 18 Gauge Stainless Steel
 5. Number of Bowls: 1
 6. Drain location: Off-center, rear.
 7. Mounting: Inside hole ratchet system equal to Elkay Quick-Clip® mounting system. Systems requiring access from below shall not be permitted.
 8. Deck Hole drilling configuration:
 - a. 2 holes, 4" apart, centered.
- B. Faucet: Zurn Z812B1-XL-HCT-3F
1. Hole configuration: 2 Hole installation, 4" centers.
 2. Spout: 5-1/2" gooseneck swing spout.
 3. Handles: Levers.
 4. Aerator: Vandal resistant, pressure compensating, 0.50 gpm
 5. Cartridges: Ceramic or compression ¼ turn.
 6. Meets ADA requirements: Yes
 7. Other:
 - a. Red & blue temperature indicators. Red = Hot, blue = cold.
- C. Basket Strainer & Tail Piece: McGuire Part Number 151
1. Material: Forged brass, chrome plated.
 2. Tailpiece: 1-1/2" x 4" 20-gauge seamless brass, chrome plated.
 3. Nuts: Cast brass lock, slip, and coupling, chrome plated
- D. Plaster Trap (Solids Interceptor): Josam 61031-1/2
1. Top Access
 2. Fixture trap type
 3. 1 ½" threaded inlet, 1 ½" threaded side outlet.
 4. Cast iron body.
 5. Cover with gasket.
 6. Removable stainless wire screen.
- E. Supplies: McGuire Part Number 2167-N3-F
1. Inlet: ½" IPS
 2. Outlet: ½" OD compression.
 3. Nipple: ½" x 3" chrome plated brass.
 4. Wall flange: Heavy brass chrome plated with set-screw.
- F. Other Manufacturers: Provide products, features, and accessories equal to those specified above.
1. Sink
 - a. Kohler
 - b. Just
 - c. Eagle Group
 2. Faucet:
 - a. Speakman
 - b. Cambridge Brass
 - c. T&S Brass
 - d. Moen

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3. Basket Strainer & Tail Piece:
 - a. Kohler
 - b. Cambridge Brass
4. Trap:
 - a. Kohler
 - b. Cambridge Brass
5. Plaster Trap:
 - a. Zurn
 - b. Wade
6. Supplies:
 - a. Cambridge Brass
 - b. Kohler

2.10 **(SK-4)** STAINLESS STEEL UTILITY SINK

- A. Manufacturer & Model Number: Elkay WNSF81302
- B. General: Stainless steel unit with stainless steel legs and backsplash.
 1. Material: 14 Gauge Stainless Steel
 2. Overall Length (Right to Left): 33"
 3. Overall Width (Front to Back): 27-1/2"
 4. Inside Bowl Depth: 14"
 5. Rim: 36"
- C. Faucet: Zurn Z842H1-XL-HCT-3F
 1. Hole configuration: 2 Hole installation, 8" centers.
 2. Spout: 8" tubular swing spout with adjustable swing limits.
 3. Handles: Levers.
 4. Aerator: Vandal-resistant, pressure-compensating, 0.50 gpm
 5. Cartridges: Ceramic or compression ¼ turn.
 6. Meets ADA requirements: Yes
 7. Other:
 - a. Red & blue temperature indicators. Red = Hot, blue = cold.
- D. Supplies:
 1. Manufacturer & Model Number: McGuire 2167-N3-F
 - a. Inlet: ½" IPS
 - b. Outlet: ½" OD compression.
 - c. Nipple: ½" x 3" chrome plated brass.
 - d. Wall flange: Heavy brass chrome plated with set-screw
- E. Drain: McGuire Part Number 152N
 1. Brass basket strainer with 4" long 1-1/2" diameter 17 gage tailpiece.
- F. Trap: McGuire Part Number 8912-C-F
 1. Size: 1-1/2" x 1-1/2"
 2. Material: Polished chrome plated cast brass.
 3. Cleanout plug: Yes
 4. Nuts: Polished chrome plated brass.

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5. Wall bend: 17-gauge seamless tubular chrome plated brass.
 6. Wall flange: Chrome plated brass with setscrew. Where pipe protrudes from wall contractor may provide deep flange.
- G. Other Manufacturers: Provide products, features, and accessories equal to those specified above.
1. Sink
 - a. Swan Corporation
 - b. Crane
 2. Faucet:
 - a. T&S
 - b. Speakman
 - c. Moen
 3. Drain:
 - a. Kohler
 - b. Cambridge Brass
 4. Trap:
 - a. Kohler
 - b. Cambridge Brass

2.11 **(WB-1)** WASHER BOX CONNECTION

- A. General: Recessed-mounting, reversible, metal washing machine outlet box with ½" IPS or copper sweat supply fittings complying with ASME A112.18.1M. Include box with faceplate, services indicated for equipment connections, and reinforcement.
- B. Manufacturer: GuyGray WB200HA
 1. ¼" turn ball valves
 2. Long shank adapters
 3. 2" drain
- C. Available Manufacturers:
 1. Acorn Engineering Company
 2. IPS Corporation, Guy Gray
 3. Oatey
 4. Symmons Industries, Inc.
 5. Zurn Industries, Inc.

2.12 **(WC-1)** FLOOR MOUNTED WATER CLOSET (ACCESSIBLE) WITH MANUAL DIAPHRAM TYPE FLUSH VALVE

- A. Manufacturer & Model Number: Zurn Z5665-BWL-AM (1.28 Gallon Flush)
- B. Material: Vitreous china
- C. Color: White
- D. Flush Valve: Zurn (1.28 Gallon Flush)
 1. Supply Rough-in Elevation: 11-1/2" above spud connection
 2. Provide:
 - a. Accessible handle located on wide side of approach.

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- b. Sweat Solder Adapter and Cast Wall Flange with Set Screw.
- E. Seat: Church 9500SSCT (White)
 - 1. Elongated extra heavy weight seat with stainless steel self-sustaining check hinge.
- F. Manufacturers:
 - 1. Water Closet
 - a. American Standard
 - b. Eljer
 - c. Crane
 - d. Gerber
 - e. Sloan
 - f. Zurn
 - 2. Flush Valve:
 - a. Delany
 - b. Zurn
 - c. Moen
 - d. Sloan
 - 3. Seat
 - a. Olsonite
 - b. Centoco

2.13 **(WH-1)** WALL HYDRANT FREEZE-RESISTANT

- A. Manufacturer & Model Number: Zurn Z1320XL-CL-WC non-freeze with recessed wall box.
- B. General: Cast bronze, non-freeze, wall hydrant with cast bronze box, satin finish face, hinged latching cover, control key, and integral vacuum breaker/backflow preventer. Pressure rating shall be 125 psig. Comply with ASME A112.21.3M, ASSE 1011, and ASSE 1019. Provide self-draining integral non-removable hose-connection, and wall clamp.
 - 1. Inlet: ¾" threaded or solder joint.
 - 2. Outlet: ASME B1.20.7, garden-hose threads.
 - 3. Operating Keys: One with each hydrant.
- C. Other Manufacturers:
 - 1. Josam
 - 2. Smith
 - 3. Woodford
 - 4. Zurn

2.14 **(WSB-1)** WATER SUPPLY BOX

- A. Manufacturer: GuyGray BIM875QTSAB
- B. General: Recessed-mounting, 20-gauge steel, outlet box& faceplate with supply fitting complying with ASME A112.18.1M. Include box with faceplate, supply valve, and reinforcement
- C. Supply valve: ½" IPS (or copper sweat) x 3/8" OD

- D. Available Manufacturers
 - 1. Guy Gray
 - 2. Water-Tite
 - 3. LSP Products Group
 - 4. Oatey

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in for water soil and for waste piping systems and supports to verify actual locations and sizes of piping connections and that locations and types of supports match those indicated, before plumbing fixture installation. Manufacturer's roughing-in data overrides all other indicated data.
- B. Examine walls, floors, and cabinets for suitable conditions where fixtures are to be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FIXTURE INSTALLATION

- A. Assemble fixtures, trim, fittings, and other components according to manufacturers' written instructions.
- B. For wall-hanging fixtures, install off-floor supports affixed to building substrate.
- C. Install back-outlet, wall hanging 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-hanging fixtures with tubular waste piping attached to supports.
- F. Install floor-mounting, back-outlet water closets attached to building floor substrate and wall bracket and onto waste fitting seals.
- G. Install counter-mounted fixtures in and attached to casework.
- H. Install fixtures level and plumb according to manufacturers' written instructions and roughing-in drawings.
- I. 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.
 - 1. Exception: Use ball valve if stops are not specified with fixture. Refer to Section "Valves".
- J. Install trap and waste piping on drain outlet of each fixture to be directly connected to sanitary drainage system.
- K. Install waste piping on drain outlet of each fixture to be indirectly connected to drainage system.

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- L. 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.
- M. Install tanks for accessible, tank-type water closets with lever handle mounted on wide side of compartment.
- N. Install toilet seats on water closets.
- O. 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.
- P. Install water supply, flow-control fittings with specified flow rates in fixture supplies at stop valves.
- Q. 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.
- R. Install shower, flow-control fittings with specified maximum flow rates in shower arms.
- S. Install traps on fixture outlets.
 - 1. Exception: Omit trap on fixtures with integral traps.
 - 2. Exception: Omit trap on indirect wastes, unless otherwise indicated.
- T. Install disposer in outlet of sinks indicated to have disposer. Install switch where indicated or in wall adjacent to sink if location is not indicated.
- U. Install hot-water dispensers in back top surface of sink or in counter with spout over sink.
- V. Install escutcheons at piping wall-ceiling penetrations in exposed, finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding fittings. Refer to Division 22 Section "Common Work Results For Plumbing" for escutcheons.
- W. Set bathtubs, shower receptors, and service basins in leveling bed of cement grout. Refer to Division 22 Section "Common Work Results for Plumbing" for grout.
- X. Refer to Section "Joint Sealants" for sealant and installation requirements.
- Y. Provide connection to automatic lavatories & flush valves as required via low-voltage transformer(s). Mount transformer(s) above accessible ceiling. Connect to local 120V receptacle circuit with disconnect switch adjacent to transformer. All circuitry (including low voltage) shall be run concealed & in conduit. Coordinate connection requirements.

3.3 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect water supplies from water distribution piping to fixtures.
- C. Connect drain piping from fixtures to drainage piping.
- D. Supply and Waste Connections to Plumbing Fixtures: Connect fixtures with water supplies, stops, risers, traps, and waste piping. Use sizes required to match fixtures. Connect to plumbing piping.
- E. Supply and Waste Connections to Fixtures and Equipment Specified in Other Sections: Connect fixtures and equipment with water supplies, stops, risers, traps, and waste piping. Use size fittings required to match fixtures and equipment. Connect to plumbing piping.

- F. Ground equipment: Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.4 FIELD QUALITY CONTROL

- A. Verify that installed fixtures are categories and types specified for locations where installed.
- B. Check that fixtures are complete with trim, faucets, fittings, and other specified components.
- C. Inspect installed 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.

3.5 ADJUSTING

- A. Replace washers and seals or cartridges of leaking and dripping faucets, stops, and valves.

3.6 CLEANING

- A. Clean fixtures, faucets, and other fittings with manufacturers' recommended cleaning methods and materials. Do the following:
 1. Remove faucet spouts and strainers, remove sediment and debris, and reinstall strainers and spouts.
 2. Remove sediment and debris from drains.

3.7 PROTECTION

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

END OF SECTION 224000

SECTION 230500 - COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Provisions of the Contract and of the Contract Documents apply to this Section.

1.2 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.
- F. The following are industry abbreviations for rubber materials:
 - 1. EPDM: Ethylene-propylene-diene terpolymer rubber.
 - 2. NBR: Acrylonitrile-butadiene rubber.

1.3 SUBMITTALS

- A. Product Data: For the following:
 - 1. Transition fittings.
 - 2. Dielectric fittings.
 - 3. Mechanical sleeve seals.
 - 4. Escutcheons.

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1.4 QUALITY ASSURANCE

- A. Equipment and appliances comprising portions of the mechanical systems regulated by the applicable building codes shall be listed and labeled in accordance with the current edition of those codes.
- B. Equipment and appliances comprising portions of the mechanical systems shall be installed in accordance with the listing, manufacturer's installation instructions, and the applicable building codes. Manufacturer's installation instructions shall be available on the job site for use and inspection.
- C. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."
- D. 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.
- E. 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.

1.5 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.

1.6 COORDINATION

- A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for HVAC 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 HVAC items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08 Section "Access Doors and Frames."

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1.7 INTENT OF CONTRACT DOCUMENTS

- A. Mechanical and HVAC drawings are diagrammatic, indicating general locations and arrangements of pipe, duct, and equipment. Not necessarily indicating all offsets, conditions, and appurtenances required to provide clearances for maximum practical accessibility to perform maintenance.
- B. Coordinate work in order to achieve proper operation and to provide a maintainable installed condition.
- C. Notify the Architect's representative immediately of conditions which do not comply or will not produce this result.
- D. Indicated configurations were used to size pipes, pumps, expansion tanks and other devices. Install piping, duct, and equipment generally as indicated. Minor deviations are permitted in the course of necessary coordination. Major changes shall be submitted for approval by the Architect's representative. Additional fittings and offsets not indicated are expected, anticipated by the design, and shall be provided. If more than 5% of the indicated number of fittings are required or if one change in direction is within six inches of another change in direction and this "Z" shape is not indicated notify the Architect's representative immediately. Provide necessary additional fittings and offsets. Changes in pipe size shall be made only with written approval from the Architect's representative.

PART 2 - PRODUCTS

2.1 PIPE, TUBE, AND FITTINGS

- A. Refer to Section "Hydronic Piping" for additional 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 23 piping sections for joining materials not listed below.
- B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions inside & outside pipe and:
 - 1. ASME B16.21, non-metallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is otherwise 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 thick, unless otherwise indicated, and full-face or ring type, unless otherwise indicated.

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- C. Solder Filler Metals: ASTM B 32, lead-free (95% Tin, 5% Antimony) alloy. Include water-flushable flux according to ASTM B 813.
- D. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg-5, silver alloy for refrigerant piping, unless otherwise indicated.
- E. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.3 DIELECTRIC FITTINGS

- A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.
- B. Insulating Material: Suitable for system fluid, pressure, and temperature.
- C. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.
 - 1. Available Manufacturers:
 - a. Capitol Manufacturing Co.
 - b. Central Plastics Company.
 - c. Epcos Sales, Inc.
 - d. Watts Industries, Inc.; Water Products Div.
- D. Dielectric-Flange Kits: Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
 - 1. Available Manufacturers:
 - a. Advance Products & Systems, Inc.
 - b. Calpico, Inc.
 - c. Central Plastics Company.
 - d. Pipeline Seal and Insulator, Inc.
 - 2. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig minimum working pressure where required to suit system pressures.
- E. Dielectric Couplings: Galvanized steel coupling with inert and non-corrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225°F.
 - 1. Available Manufacturers:
 - a. Calpico, Inc.
 - b. Lochinvar Corp.

2.4 MECHANICAL SLEEVE SEALS

- A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
 - 1. Available Manufacturers:
 - a. Advance Products & Systems, Inc.
 - b. Calpico, Inc.
 - c. Metraflex Co.
 - d. Pipeline Seal and Insulator, Inc.
 - 2. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
 - 3. Pressure Plates: Plastic. Include two for each sealing element.
 - 4. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements.

2.5 SLEEVES

- A. Galvanized-Steel Sheet: 0.0239-inch 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.
- E. Molded PE: Reusable, PE, tapered cup-shaped and smooth-outer surface with nailing flange for attaching to wooden forms.

2.6 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. One-Piece, Floor-Plate Type: Cast-iron floor plate.
- F. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

2.7 GROUT

- A. Description: ASTM C 1107, Grade B, non-shrink and non-metallic, dry hydraulic cement grout.
 - 1. Characteristics: Post-hardening, volume-adjusting, non-staining, non-corrosive, non-gaseous, and recommended for interior and exterior applications.
 - 2. Design Mix: 5000-psi, 28-day compressive strength.
 - 3. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 HVAC DEMOLITION

- A. Refer to Sections "Cutting and Patching" and "Selective Structure Demolition" for general demolition requirements and procedures.
- B. Disconnect, demolish, and remove HVAC systems, equipment, and components indicated to be removed.
 - 1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
 - 2. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.
 - 3. Equipment to Be Removed: Remove equipment and associated piping back to main unless otherwise indicated. Cap services.
 - 4. Equipment to Be Removed and Reinstalled: Disconnect and cap services. Remove, clean, and store equipment. When appropriate, reinstall, reconnect, and make equipment operational.
 - 5. Equipment to Be Removed and Salvaged: Remove equipment and associated piping back to main unless otherwise indicated. Cap services. Remove equipment, clean, and store as directed (May be off-site). Make available to owner at time of the owner's choosing.
- C. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

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3.2 PIPING SYSTEMS - COMMON REQUIREMENTS

- A. Install piping according to the following and Division 23 Sections specifying piping systems.
- B. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
- C. 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.
- D. Install piping above accessible ceilings allowing sufficient space for ceiling panel removal.
- E. Install piping to permit valve operation & servicing.
- F. Install condensate drain piping at 1% slope.
- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections unless otherwise indicated.
- I. Install piping leaving room for installation of insulation.
- J. Install system components with pressure rating equal to or greater than system operating pressure.
- K. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:
 - 1. Exposed, Interior Installations/Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
 - 2. Exposed, Interior Installations/Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish and set-screw.
 - 3. Exposed, Interior Installations/Insulated Piping: One-piece, cast-brass type with polished chrome-plated finish.
 - 4. Exposed, Interior Installations/Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with finish to match surrounding surfaces.
 - 5. Exposed, Interior Installations/Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece or split-casting, cast-brass type with finish to match surrounding surfaces.
 - 6. Exposed, Interior Installations/Piping in Unfinished Service Spaces: None, provide sealant.
 - 7. Exposed, Interior Installations/Piping in Equipment Rooms: None, provide sealant.
 - 8. Exposed, Interior Installations/Piping at Floor Penetrations in Equipment Rooms, Fan Rooms, or similar wet spaces: None - provide sealant and sleeve extending 2" above floor to prevent liquid leaking to floor below.
- L. Provide seal around piping penetrations of full height interior walls, both rated and non-rated, that occur above ceilings. Refer to Section 079200 Joint Sealants.
- M. Sleeves are not required for core-drilled holes.
 - 1. Exception: Exposed, Interior Installations at Floor Penetrations in Equipment Rooms, Fan Rooms, or similar wet spaces.

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- N. Permanent sleeves are not required for holes formed by removable PE sleeves.
1. Exception: Exposed, Interior Installations at Floor Penetrations in Equipment Rooms, Fan Rooms, or similar wet spaces.
- O. Install sleeves for pipes passing through walls, floors, or roofs.
1. Cut sleeves to length for mounting flush with both surfaces.
 - a. Exception: Extend sleeves installed in floors of mechanical equipment rooms, fan rooms or other similar wet areas 2 inches above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring.
 2. Install sleeves as walls and slabs are constructed.
 - a. PVC Pipe Sleeves: Permitted for pipes smaller than 6" except aboveground, exterior-walls.
 - b. Steel Sheet Sleeves: Permitted for pipes 6" and larger, penetrating gypsum-board partitions except aboveground, exterior-walls.
 - c. Seal space outside sleeve fittings with grout and sealant.
 3. Except for penetrations where mechanical sleeve seals are used, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Section "Joint Sealants".
- P. Aboveground Exterior Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for annular clear space required by the mechanical sleeve seal manufacturer between pipe and sleeve for installing mechanical sleeve seals.
1. Install steel pipe for sleeves smaller than 6 inches in diameter.
 2. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter.
 3. 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.
 4. Sleeves from an approved sleeve seal manufacturer shall be acceptable.
- Q. Underground Exterior Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for annular clear space required by the mechanical sleeve seal manufacturer between pipe and sleeve for installing mechanical sleeve seals.
- R. 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.
- S. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Section "Penetration Firestopping" for materials.

- T. Verify final equipment locations for roughing-in.
- U. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.3 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 water-flushable flux, unless otherwise indicated, to tube end. Construct joints using lead-free solder alloy.
- E. Brazed Joints: Construct joints using copper-phosphorus brazing filler metal.
- F. Threaded Joints: Thread pipe with tapered pipe threads. 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 otherwise indicated.
- G. Welded Joints: Construct joints using qualified processes and welding operators.
- H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
- I. Mechanical Joints: Prepare pipe ends and fittings, apply coupling, and join according to joint manufacturer's written instructions.

3.4 PIPING CONNECTIONS

- A. Make connections according to the following, unless otherwise indicated:
 - 1. Install unions, in piping 2" and smaller, one adjacent to each valve and at final connections to each piece of equipment.
 - 2. Install flanges, in piping NPS 2-1/2" and larger, adjacent to final connections to each piece of equipment.
 - 3. Install dielectric unions or flanges for connections of dissimilar metals.

3.5 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

- A. Install equipment to allow maximum possible headroom unless specific mounting heights are 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 service side of equipment.
- D. Install equipment to allow space for other systems.

3.6 PAINTING

- A. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.7 HOUSEKEEPING PADS AND EQUIPMENT PADS

- A. Housekeeping pads and equipment pads: Anchor equipment to concrete according to equipment manufacturer's written instructions and according to seismic codes at project location.
 - 1. Construct concrete pads in accordance with drawing details.
 - 2. Details may be found on structural drawings. If details are not provided comply with the following:
 - a. Housekeeping pads inside the building shall be 6" thick and 6" larger all around than supported equipment. Provide #4 rebar at 12" on center each way at mid-depth of slab. Provide a 3/4" chamfer on all edges.
 - b. Equipment pads outside the building shall be 8" thick with a 12" deep and 20" wide turndown (footing) all around the outside edge of the pad. Provide #5 rebar at 16" on center each way at mid-depth of slab. Pad shall be 6" larger all around than supported equipment.
 - c. Install epoxy-coated anchor bolts. For equipment on housekeeping pads bolts shall extend through housekeeping pad, and anchor into structural concrete floor.
 - d. Place and secure anchor bolts using supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions for placement.
 - e. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - f. Install anchor bolts according to anchor bolt manufacturer's written instructions.
 - g. Use 3000-psi, 28-day compressive-strength concrete and reinforcement as specified in Section "Cast-in-Place Concrete".

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3.8 ERECTION OF METAL SUPPORTS AND ANCHORAGES

- A. Refer to Section "Metal Fabrications" for structural steel.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor HVAC materials and equipment.
- C. Field Welding: Comply with AWS D1.1.

3.9 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.

3.10 EXCAVATION AND BACKFILL

- A. Excavation and backfill shall be as indicated in Division 1 specifications and on the drawings. If excavation and backfill is not otherwise indicated the following shall apply:
 - 1. Excavate trenches to indicated gradients, lines, depths, and elevations.
 - a. Beyond the building perimeter, excavate trenches to allow installation of top of pipe below frost line.
 - 2. Excavate trenches to uniform widths to provide twelve inches clear on each side of pipe. Excavate trench walls vertically from trench bottom.
 - 3. Trench Bottoms: Excavate trench bottoms to provide flat surface. Place and compact six inches of sand. Excavate and shape sand to provide uniform bearing and support of pipes. Shape sand to provide continuous support for bells, joints, fittings, and barrels of pipes. Sand shall be free of projecting stones and sharp objects.
 - 4. Backfill and hand tamp to 95% proctor to six inches above the top of the pipe.
 - 5. Backfill and machine tamp the remainder of the trench to 95% proctor in twelve inch lifts.

END OF SECTION 230500

SECTION 230513 – MOTORS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Provisions of the Contract and of the Contract Documents apply to this Section.

1.2 SUBMITTALS

- A. Manufacturer's catalog and efficiency 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. Comply with NFPA 70.

1.4 COORDINATION

- A. All motors are required to be equipped with overload protection located near the motor.
 - 1. Overload protection shall:
 - a. Be located between the circuit breaker or fuse provided under Division 26 and the motor windings.
 - b. Meet one of the options specified in the following paragraph.
 - 2. Overload protection may be:
 - a. Located in the motor installed by the motor manufacturer. (preferred)
 - b. A separate device located near the motor.
 - c. Located in, or with, a disconnect switch provided by the equipment manufacturer. Provision of this switch shall not modify, change, or eliminate any Division 26 requirement. This means some equipment shall be provided or specified with two disconnecting means.
- B. Coordinate features of motors, installed units, and accessory devices. Provide motors that are:
 - 1. Compatible with controller
 - 2. Matched to torque and horsepower requirements of the load.
 - 3. Matched to ratings and characteristics of supply circuit and required control sequence.
- C. Coordinate motor support with requirements for driven load; access for maintenance and motor replacement; installation of accessories, belts, belt guards; and adjustment of sliding rails for belt tensioning.
- D. Belt tension must be wrench and socket adjustable.
- E. Belt tensioning device must accommodate adjustable sheaves.

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PART 2 - PRODUCTS

2.1 MOTOR REQUIREMENTS

- A. Motor requirements apply except as follows:
1. Ratings, performance, or characteristics for a motor are specified in another Section or are scheduled on the drawings.
 2. Motor manufacturer requires ratings, performance, or characteristics, other than those specified to meet indicated performance.

2.2 MOTOR CHARACTERISTICS

- A. Frequency Rating: 60 Hz.
- B. Voltage Rating: NEMA standard voltage selected to operate on nominal circuit voltage to which motor is connected.
- C. Duty: Continuous at 105 deg F and 3300 feet above sea level.
- D. Capacity and Torque sufficient to:
1. Start, accelerate, and operate connected load.
 2. Maintain designated speeds.
 3. Operate at installed altitude and environment.
 4. Operate with indicated operating sequence.
 5. Operate without exceeding nameplate ratings.
 6. Operate without utilizing service factor.
- E. Enclosure: Open drip-proof unless otherwise indicated.
- F. Minimum Service Factor: 1.15 unless otherwise indicated.

2.3 POLYPHASE MOTORS

- A. Description: NEMA MG 1, Design B, medium induction motor.
- B. NEMA Premium efficiency motors shall meet the following full load efficiency:

HP	ODP			TEFC		
	6 Pole	4 Pole	2 Pole	6 Pole	4 Pole	2 Pole
1	82.5	85.5	77.0	82.5	85.5	77.0
1.5	86.5	86.5	84.0	87.5	86.5	84.0
2	87.5	86.5	85.5	88.5	86.5	85.5
3	88.5	89.5	85.5	89.5	89.5	86.5
5	89.5	89.5	86.5	89.5	89.5	88.5
7.5	90.2	91.0	88.5	91.0	91.7	89.5
10	91.7	91.7	89.5	91.0	91.7	90.2
15	91.7	93.0	90.2	91.7	92.4	91.0
20	92.4	93.0	91.0	91.7	93.0	91.0
25	93.0	93.6	91.7	93.0	93.6	91.7
30	93.6	94.1	91.7	93.0	93.6	91.7

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40	94.1	94.1	92.4	94.1	94.1	92.4
50	94.1	94.5	93.0	94.1	94.5	93.0
60	94.5	95.0	93.6	94.5	95.0	93.6
75	94.5	95.0	93.6	94.5	95.4	93.6
100	95.0	95.4	93.6	95.0	95.4	94.1
125	95.0	95.4	94.1	95.0	95.4	95.0
150	95.4	95.8	94.1	95.8	95.8	95.0

- C. Efficiency: NEMA Premium
- D. Stator: Copper windings, unless otherwise indicated.
- E. Rotor: Squirrel cage, unless otherwise indicated.
- F. Bearings: Double-shielded, pre-lubricated ball bearings suitable for radial and thrust loading.
- G. Temperature Rise: Match insulation rating, unless otherwise indicated.
- H. Insulation: Class F, unless otherwise indicated.
- I. Code Letter Designation: NEMA starting Code F or G.
- J. Enclosure: Cast iron.
- K. Finish: Gray enamel.
- L. Motors Used with Reduced-Inrush Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.
- M. Motors Used with Variable Speed Drives: 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. Premium Efficiency 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. Shaft Grounding: Provide AEGIS bearing protection ring or approved equal.
 - a. All motors operated on variable frequency drives shall be equipped with a maintenance free, conductive micro fiber, shaft grounding ring with a minimum of two rows of circumferential micro fibers to discharge electrical shaft currents within the motor and/or its bearings.
 - b. Motors up to 100 HP shall be provided with a minimum of one shaft grounding ring installed either on the drive end or non-drive end. Motors over 100 HP shall be provided with an insulated bearing on the non-drive end and a shaft grounding ring on the drive end of the motor.
 - c. Grounding rings shall be provided and installed by the motor manufacturer in accordance with the shaft grounding ring manufacturer's recommendations.

- N. Source Quality Control: Perform the following tests on each motor according to NEMA MG 1:
1. Measure winding resistance.
 2. Read no-load current and speed at rated voltage and frequency.
 3. Measure locked rotor current at rated frequency.
 4. Perform high-potential test.

PART 3 - EXECUTION

3.1 FIELD QUALITY CONTROL

- A. Perform the following:
1. Run each motor with its controller at load.
 2. Demonstrate correct rotation, alignment, and speed.
 3. Test interlocks and control features for proper operation.
 4. Verify that current in each phase is within nameplate rating.
 5. Verify RPM is in accordance with nameplate.
 6. Where a generator is provided, run each motor on the generator with its controller and load. Demonstrate correct rotation, alignment, and speed.

3.2 ADJUSTING

- A. Align motors, bases, and shafts.

3.3 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.

END OF SECTION 230513

SECTION 230514 – VARIABLE SPEED DRIVES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Provisions of the Contract and of the Contract Documents apply to this Section.

1.2 DEFINITIONS

- A. Factory Installed Variable Speed Drive: A drive installed by motorized-equipment manufacturer as a component of equipment utilized to control the speed of a motor.
- B. Field-Installed Variable Speed Drive: A drive installed in the field by the contractor to control the speed of a motor not equipped with a factory installed drive.
- C. VSD: Variable Speed Drive

1.3 SUBMITTALS

- A. Submittals shall include the following information:
 - 1. Outline dimensions
 - 2. Conduit entry locations
 - 3. Weight.
- B. Customer connection and power wiring diagrams.
- C. Technical product description including but not limited to a complete list of options.
- D. Compliance with IEEE 519 – Provide a harmonic analysis specific to the project including total harmonic voltage distortion and total harmonic current distortion (TDD). Analysis shall include all HVAC loads and all equipment with VFDs.
- E. The VFD manufacturer shall provide calculations; specific to this installation, showing total harmonic voltage distortion is less than 5%. Provide additional harmonic filtration devices as required to achieve a total harmonic voltage distortion of less than 5%.
- F. All VFDs shall include a minimum of 5% impedance reactors.

1.4 QUALITY ASSURANCE

- A. VSDs and options shall be UL listed as a complete assembly.
- B. The base VSD shall be UL listed for 100 KAIC without the need for input fuses.

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- C. The VSD shall be tested by the manufacturer.
- D. All optional features shall be functionally tested at the factory for proper operation.
- 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. Comply with UL 508C.
- F. Referenced standards:
 - 1. Standard 519-1992, IEEE Guide for Harmonic Content and Control.
 - 2. UL508C
 - 3. ICS 7.0, AC Adjustable Speed Drives
 - 4. IEC 16800 Parts 1, 2 and 3NEC 430.120, Adjustable-Speed Drive Systems
 - 5. IBC 2012 Seismic – referencing ASC 7-05 and ICC AC-156
- G. All VSDs installed on this project shall be from the same manufacturer.
- H. The VSD enclosure shall be seismically certified and labeled in accordance with the IBC 2012 International Building Code:
 - 1. VSD manufacturer shall provide Seismic Certification and Installation requirements at time of submittal.
 - 2. A Seismic importance factor of 1.5 shall be used and shall be based upon actual shake test data as defined by ICC AC-156. Seismic ratings based upon calculations alone are not acceptable.
 - 3. Certification of Seismic rating must be based on testing done in all three axis of motion by a certified lab.
- I. Installations in life safety applications including but not limited to smoke removal and make up air to smoke removal systems shall be included in the seismic approval.

1.5 WARRANTY

- A. The VSD shall be warranted by the manufacturer for a period of 2 Years from Date of Substantial Completion. The warranty shall include parts, labor, travel costs and living expenses incurred by the manufacturer to provide factory authorized on-site service. The warranty shall be provided by the VSD manufacturer.

1.6 COORDINATION

- A. Coordinate features of VSDs with motors, installed units, and accessory devices. Provide VSDs that meet the requirements indicated in this and other equipment specific specification sections.
- B. Confirm that motors controlled by VSDs, provided under this section are designed and labeled for use with variable speed drives, and suitable for use throughout speed range without overheating.

- C. Coordinate VSD support with requirements for maintenance and replacement; and installation of accessories.

PART 2 - PRODUCTS

2.1 FACTORY INSTALLED VARIABLE SPEED DRIVES

- A. The VSD shall be enclosed in a UL Listed enclosure.
- B. Refer to equipment specific specification sections.
- C. Where equipment specific specification sections do not indicate variable speed drive requirements comply with 2.2 below.

2.2 FIELD-INSTALLED VARIABLE SPEED DRIVES

- A. Manufacturers
 - 1. Basis of Design – ABB
 - 2. Trane
 - 3. Yaskawa
 - 4. Danfoss-Graham
- B. General
 - 1. Furnish complete variable speed drives (VSDs) as indicated.
 - 2. Drawing schedules, sequences of control, control diagrams, details, or other specification sections may indicate variable speed requirements.
 - 3. All standard and optional features shall be included within the VSD enclosure, unless indicated otherwise. Each VSD shall be housed in a NEMA 1 enclosure, or other NEMA type according to installation and operating conditions.
 - 4. Provide NEMA 3R weatherproof enclosures for drives mounted outside.
 - 5. The UL listing shall allow mounting in a plenum or other air handling compartment. If a NEMA 12 enclosure is required for the plenum rating, the manufacturer shall supply a NEMA 12 rated VSD.
 - 6. A bypass is not required unless indicated otherwise.
- C. The VSD shall convert incoming fixed frequency three-phase AC power into a variable frequency and voltage for controlling the speed of three-phase AC motors. The motor current shall closely approximate a sine wave. Motor voltage shall be varied with frequency to maintain desired motor magnetization current. Operation shall be suitable for centrifugal pump and fan control and shall eliminate the need for motor de-rating.
- D. With the motor's rated voltage applied to the VSD input, the VSD shall allow the motor to produce full rated power at rated amps, RMS fundamental volts, and speed without using the motor's service factor. VSDs utilizing sine weighted/coded modulation (with or without 3rd

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harmonic injection) must provide data verifying that the motors will not draw more than full load current during full load and full speed operation.

- E. The VSD shall include an input full-wave bridge rectifier and maintain a fundamental power factor near unity regardless of speed or load.
- F. The VSD and options shall be tested to ANSI/UL Standard 508. The complete VSD, including all specified options, shall be assembled by the manufacturer and shall be UL-508 certified for the building and drive assembly including options. Assembly of the options by a third-party panel shop is not acceptable. The appropriate UL stickers shall be applied to both the VSD and option panel, in the case where these are not contained in one panel.
- G. The VSD shall have DC link reactors on both the positive and negative rails of the DC bus to minimize power line harmonics. VSDs without DC link reactors shall provide a minimum 3% impedance line reactor.
- H. The VSD's full load amp rating shall meet or exceed NEC Table 430-150. The VSD shall be able to provide full rated output current continuously, 110% of rated current for 60 seconds and 160% of rated current for up to 0.5 second while starting.
- I. The VSD shall be able to provide full torque at any selected frequency from 28 Hz to base speed to allow driving direct drive fans without derating.
- J. An automatic energy optimization selection feature shall be provided standard in the VSD. This feature shall automatically and continually monitor the motor's speed and load and adjust the applied voltage to maximize energy savings and provide up to an additional 3% to 10% energy savings.
- K. Input and output power circuit switching shall be able to be accomplished without interlocks or damage to the VSD. Switching rate may be up to 1 time per minute on the input and unlimited on the output.
- L. An automatic motor adaptation test algorithm shall measure motor stator resistance and reactance to optimize performance and efficiency. It shall not be necessary to run the motor or de-couple the motor from the load to run the test.
- M. Galvanic and/or optical isolation shall be provided between the VSD's power circuitry and control circuitry to ensure operator safety and to protect connected electronic control equipment from damage caused by voltage spikes, current surges, and ground loop currents. VSDs not including either galvanic or optical isolation on both analog I/O and discrete I/O shall include additional isolation modules.
- N. VSD shall minimize the audible motor noise through the use of an adjustable carrier frequency. The carrier frequency shall be automatically adjusted to optimize motor and VSD efficiencies while reducing motor noise.
- O. Protective Features:
 - 1. Disconnect with drive fusing.

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2. A minimum of Class 20 I²t electronic motor overload protection for single motor applications and thermal-mechanical overloads for multiple motor applications shall be provided.
3. Protection against input transients, loss of AC line phase, output short circuit, output ground fault, overvoltage, undervoltage, VSD overtemperature and motor overtemperature. The VSD shall display all faults in plain English. Codes are not acceptable.
4. Protect VSD from sustained power or phase loss. The VSD shall provide full rated output with an input voltage as low as 90% of the nominal. The VSD will continue to operate with reduced output with an input voltage as low as 164 V AC for 208/230 volt units, and 313 V AC for 460 volt units.
5. The VSD shall incorporate a motor preheat circuit to keep the motor warm and prevent condensation build up in the stator.
6. VSD package shall include semi-conductor rated input fuses to protect power components.
7. To prevent breakdown of the motor winding insulation, the VSD shall be designed to comply with IEC Part 34-17. Otherwise, the VSD manufacturer must ensure that inverter rated motors are supplied.
8. VSD shall include a "signal loss detection" circuit to sense the loss of an analog input signal such as 4 to 20 mA or 2 to 10 V DC, and shall be programmable to react as desired in such an instance.
9. VSD shall function normally when the keypad is removed while the VSD is running and continue to follow remote commands. No warnings or alarms shall be issued as a result of removing the keypad.
10. VSD shall catch a rotating motor operating forward or reverse up to full speed.
11. VSD shall be rated for 100,000 amp interrupting capacity (AIC).
12. VSD shall include current sensors on all three output phases to detect and report phase loss to the motor. The VSD will identify which of the output phases is low or lost.
13. VSD shall continue to operate without faulting until input voltage reaches 300 V AC on 208/230 volt VSDs, and 539 V AC on 460 volt VSDs.

P. Interface Features:

1. Hand/Start, Off/Stop and Auto/Start selector switches shall be provided to start and stop the VSD and determine the speed reference.
2. The VSD shall be able to be programmed to provide a 24 V DC output signal to indicate that the VSD is in Auto/Remote mode.
3. The VSD shall provide potentiometer speed control. Electronic speed controls are not acceptable.
4. Lockable, alphanumeric backlit display keypad can be remotely mounted up to 10 feet away using standard 9-pin cable.
5. The keypads for all sizes of VSDs shall be identical and interchangeable.
6. To set up multiple VSDs, it shall be possible to upload all setup parameters to the VSD's keypad, place that keypad on all other VSDs in turn and download the setup parameters to each VSD. To facilitate setting up VSDs of various sizes, it shall be possible to download from the keypad only size independent parameters.
7. Display shall be programmable to display in 9 languages including English, Spanish and French.
8. The display shall have four lines, with 20 characters on three lines and eight large characters on one line.

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9. A red FAULT light, a yellow WARNING light and a green POWER-ON light shall be provided. These indications shall be visible both on the keypad and on the VSD when the keypad is removed.
10. A quick setup menu with factory preset typical HVAC parameters shall be provided on the VSD eliminating the need for macros.
11. The VSD shall include a standard RS-485 communications port.
12. As a minimum, the following points shall be controlled and/or accessible:
 - a. VSD Start/Stop
 - b. Speed reference
 - c. Fault diagnostics
 - d. Meter points
 - e. Motor power in HP
 - f. Motor power in kW
 - g. Motor kW-hr
 - h. Motor current
 - i. Motor voltage
 - j. Hours run
 - k. Feedback signal #1
 - l. Feedback signal #2
 - m. DC link voltage
 - n. Thermal load on motor
 - o. Thermal load on VSD
 - p. Heat sink temperature
13. Four additional Form C 230 volt programmable relays shall be available for factory or field installation within the VSD.
14. LonWorks communication shall be available for factory or field installation within the VSD.
15. Two set-point control interface (PID control) shall be standard in the unit. VSD shall be able to look at two feedback signals, compare with two set-points and make various process control decisions.
16. Floating point control interface shall be provided to increase/decrease speed in response to contact closures.
17. Four simultaneous displays shall be available. They shall include frequency or speed, run time, output amps and output power. VSDs unable to show these four displays simultaneously shall provide panel meters.
18. Sleep mode shall be provided to automatically stop the VSD when its speed drops below set "sleep" level for a specified time. The VSD shall automatically restart when the speed command exceeds the set "wake" level.
19. The sleep mode shall be functional in both follower mode and PID mode.
20. Run permissive circuit shall be provided to accept a "system ready" signal to ensure that the VSD does not start until dampers or other auxiliary equipment are in the proper state for VSD operation. The run permissive circuit shall also be capable of sending an output signal as a start command to actuate external equipment before allowing the VSD to start.
21. The following displays shall be accessible from the control panel in actual units: Reference Signal Value in actual units, Output Frequency in Hz or percent, Output Amps, Motor HP, Motor kW, kW-hr, Output Voltage, DC Bus Voltage, VSD Temperature in degrees, and Motor Speed in engineering units per application (in GPM, CFM, etc.). VSD

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will read out the selected engineering unit either in a linear, square or cubed relationship to output frequency as appropriate to the unit chosen.

22. The display shall be programmed to read in inches of water column (in-wg) for an air handler application, pressure per square inch (psi) for a pump application, and temperature (°F) for a cooling tower application.
23. VSD shall be able to be programmed to sense the loss of load and signal a no load/broken belt warning or fault.
24. If the temperature of the VSD's heat sink rises to 80°C, the VSD shall automatically reduce its carrier frequency to reduce the heat sink temperature. If the temperature of the heat sink continues to rise the VSD shall automatically reduce its output frequency to the motor. As the VSD's heat sink temperature returns to normal, the VSD shall automatically increase the output frequency to the motor and return the carrier frequency to its normal switching speed.
25. The VSD shall have temperature controlled cooling fans for quiet operation and minimized losses.
26. The VSD shall store in memory the last 10 faults and related operational data.
27. Eight programmable digital inputs shall be provided for interfacing with the systems control and safety interlock circuitry.
28. Two programmable relay outputs, one Form C 240 V AC, one Form A 30 V AC, shall be provided for remote indication of VSD status.
29. Three programmable analog inputs shall be provided and shall accept a direct-or-reverse acting signal. Analog reference inputs accepted shall include two voltage (0 to 10 V DC, 2 to 10 V DC) and one current (0 to 20 mA, 4 to 20 mA) input.
30. Two programmable 0 to 20 mA analog outputs shall be provided for indication of VSD status. These outputs shall be programmable for output speed, frequency, current and power. They shall also be programmable to provide a selected 24 V DC status indication.
31. Under fire mode conditions, the VSD shall be able to be programmed to automatically default to a preset speed.

Q. Adjustments

1. VSD shall have an adjustable carrier frequency in steps of not less than 0.1 kHz to allow tuning the VSD to the motor.
2. Sixteen preset speeds shall be provided.
3. Four acceleration and four deceleration ramps shall be provided. Acceleration and deceleration times shall be adjustable over the range from 0 to 3,600 seconds to base speed. The shape of these curves shall be automatically contoured to ensure no-trip acceleration and deceleration.
4. Four current limit settings shall be provided.
5. If the VSD trips on one of the following conditions, the VSD shall be programmable for automatic or manual reset: undervoltage, overvoltage, current limit and inverter overload.
6. The number of restart attempts shall be selectable from 0 through 20 or infinitely and the time between attempts shall be adjustable from 0 through 600 seconds.
7. An automatic "on delay" may be selected from 0 to 120 seconds.

R. Service Conditions

1. Ambient temperature, -10 to 40°C (14 to 104°F).
2. 0 to 95% relative humidity, non-condensing.
3. Elevation to 3,300 feet without derating.

4. AC line voltage variation, -10 to +10% of nominal with full output.
5. No side clearance shall be required for cooling of any units. All power and control wiring shall be done from the bottom.

PART 3 - EXECUTION

3.1 FIELD QUALITY CONTROL

A. Examination

1. Contractor to verify that job site conditions for installation meet factory recommended and code-required conditions for VSD installation prior to start-up, including clearance spacing, temperature, contamination, dust, and moisture of the environment. Separate conduit installation of the motor wiring, power wiring, and control wiring, and installation per the manufacturer's recommendations shall be verified.
2. The VSD is to be covered and protected from installation dust and contamination until the environment is cleaned and ready for operation. The VSD shall not be operated while the unit is covered.

B. Start-up Service

1. The manufacturer shall provide start-up commissioning of the VSD and its optional circuits by a factory certified service technician who is experienced in start-up and repair services. Sales personnel and other agents who are not factory certified shall not be acceptable as commissioning agents. Start-up services shall include checking for verification of proper operation and installation for the VSD, its options and its interface wiring to the building automation system.

- 3.2 CLEANING: After completing equipment installation, inspect unit components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

END OF SECTION 230514

SECTION 230517 - SLEEVES AND SLEEVE SEALS FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Provisions of the Contract and of the Contract Documents apply to this Section.

1.2 SUBMITTALS

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

PART 2 - PRODUCTS

2.1 SLEEVES

- A. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.
- B. Galvanized-Steel Wall Pipes: ASTM A 53/A 53M, Schedule 40, with plain ends and welded steel collar; zinc coated.
- C. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.
- D. Galvanized-Steel-Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

2.2 STACK-SLEEVE FITTINGS

- A. Available Manufacturers:
 - 1. Smith, Jay R. Mfg. Co.
 - 2. Wade
 - 3. Zurn Specification Drainage Operation; Zurn Plumbing Products Group.
- B. Description: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring, bolts, and nuts for membrane flashing.
 - 1. Underdeck Clamp: Clamping ring with setscrews.

2.3 SLEEVE-SEAL SYSTEMS

- A. Available Manufacturers:

1. Advance Products & Systems, Inc.
 2. CALPICO, Inc.
 3. Link Seal
 4. Metraflex Company (The).
 5. Pipeline Seal and Insulator, Inc.
 6. Proco Products, Inc.
- B. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
1. Sealing Elements: EPDM or Nitrile 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.

2.4 GROUT

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

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

- A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.
- B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.
 1. Sleeves are not required for core-drilled holes.
- C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
 1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
 2. Cut sleeves to length for mounting flush with both surfaces.
 - a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.

3. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.

1. Cut sleeves to length for mounting flush with both surfaces.
2. Install sleeves that are large enough to provide ¼" clear space between sleeve and pipe or pipe insulation.
3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants.

E. Fire Ratings: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials.

3.2 STACK-SLEEVE-FITTING INSTALLATION

A. Install stack-sleeve fittings in new slabs as slabs are constructed.

1. Install fittings that are large enough to provide ¼" clear space between sleeve and pipe or pipe insulation.
2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Division 07 Section "Sheet Metal Flashing and Trim."
3. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level.
4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
5. Using grout, seal the space around outside of stack-sleeve fittings.

B. Fire Rating: Maintain indicated fire rating at pipe penetrations. Seal pipe penetrations with firestop materials.

3.3 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building unless otherwise indicated. They are not required at sanitary and storm piping exits unless otherwise indicated.

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

3.4 SLEEVE AND SLEEVE-SEAL SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:

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1. Exterior Concrete Walls above Grade, below Grade, Concrete Slabs-on-Grade, and Concrete Slabs above Grade:
 - a. Piping Smaller Than NPS 6: Cast-iron wall sleeves with sleeve-seal system.
 - 1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
 - b. Piping NPS 6 and Larger: Galvanized-steel-pipe sleeves with sleeve-seal system.

END OF SECTION 230517

SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Provisions of the Contract and of the Contract Documents apply to this Section.

1.2 DEFINITIONS

- A. MSS: Manufacturers Standardization Society of the Valve and Fittings Industry Inc.
- B. Terminology as defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

1.3 PERFORMANCE REQUIREMENTS

- A. Design Requirement: Design trapeze pipe hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer where using methods other than indicated.
- B. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.
 - 1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test medium.
 - 2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

1.4 QUALITY ASSURANCE

- A. Structural Steel 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.

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

- A. Carbon-Steel Pipe Hangers and Supports:

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1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Pre-galvanized or hot dipped.
3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

B. Copper Pipe Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel.

2.2 TRAPEZE PIPE HANGERS

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

- B. Trapeze Pipe Hanger Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled channel systems.

1. Assemble and provide according to manufacturer's written instructions. Center piping on channel to evenly distribute load.
2. Pipe sizes and numbers shall be in accordance with the following:

TRAPEZE PIPE HANGER TABLE								
PIPE SIZE	4"	3"	2 ½"	2"	1 ½"	1 ¼"	1"	TOTAL # of PIPES
NUMBER OF PIPES PERMITTED IN ONE CHANNEL SUPPORT	2	0	0	0	0	0	0	2
	0	2	2	0	0	0	0	4
	0	2	0	4	0	0	0	6
	0	2	0	0	6	0	0	8
	0	0	4	2	0	0	0	6
	0	0	4	0	2	2	0	8
	0	0	4	0	0	8	0	12
	0	0	0	6	2	2	2	12
	0	0	0	8	0	2	0	10
	0	0	0	0	14	0	0	14
	0	0	0	0	0	16	0	16

Notes:

1. Piping larger than 4" in diameter is not permitted in a channel support system.
2. Channel support systems shall be limited to eight (8) pipes per channel and two (2) channels (levels) per support system.
3. Smaller pipes can be substituted for larger pipes. For example two ¾" pipes may be installed in lieu of two 1" pipes, or 2" in lieu of 3", etc.
4. Spacing shall be in accordance with requirements for the smallest supported pipe. Refer to other specification sections for spacing requirements. If spacing requirements are not indicated comply with MSS SP-69.

C. Metal Framing Systems:

1. Available Manufacturers:
 - a. Anvil International; a subsidiary of Mueller Water Products Inc.
 - b. Empire Industries, Inc.
 - c. ERICO International Corporation.
 - d. Haydon Corporation; H-Strut Division.
 - e. NIBCO INC.
 - f. PHD Manufacturing, Inc.
 - g. PHS Industries, Inc.
2. Description: Shop- or field-fabricated pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
3. Standard: Comply with MFMA-4.
4. Channels: Continuous slotted steel channel with inturned lips.
5. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
6. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.
7. Coating: Zinc.

2.3 THERMAL-HANGER SHIELD INSERTS

A. Available Manufacturers:

1. Carpenter & Paterson, Inc.
2. Clement Support Services.
3. ERICO International Corporation.
4. National Pipe Hanger Corporation.
5. PHS Industries, Inc.
6. Pipe Shields, Inc.; a subsidiary of Piping Technology & Products, Inc.
7. Piping Technology & Products, Inc.
8. Rilco Manufacturing Co., Inc.
9. Value Engineered Products, Inc.

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- B. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with 100-psig or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig minimum compressive strength and vapor barrier.
- C. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate with 100-psig, ASTM C 552, Type II cellular glass with 100-psig, or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig minimum compressive strength.
- 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" beyond sheet metal shield for piping operating below ambient air temperature.

2.4 PIPE STANDS

- A. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.
 - 1. Available Manufacturers:
 - a. Cooper B-Line – Dura-Blok
 - b. MAPA Products
 - c. Mifab, Inc. – C-Port
 - d. Miro Industries, Inc.
 - e. OMG, Inc.
 - f. PHP Systems/Design
 - g. Pipe Prop
 - h. Roof Top Blox
 - i. Rooftop Support Systems – Eberl Iron Works, Inc.
 - 2. Provide pipe supports for supporting gas, condensate, refrigeration lines, or hydronic piping on flat roof surfaces. Support shall rest on roof surface without penetrating the roof surface. Supports for condensate piping shall be adjustable vertically to ensure pipe slopes as required.
- B. Compact Pipe Stand: One-piece plastic unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.
- C. Curb Mounted Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

2.5 EQUIPMENT SUPPORTS/RAILS

- A. Description: Welded, shop or field fabricated equipment support made from structural carbon-steel shapes unless indicated otherwise.
 - 1. Available Manufacturers:

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- a. Curbs Plus, Inc. – CPES-X
 - b. Kees – Equipment Support Model SF
 - c. Pate Company – Equipment Support ES-2
 - d. Portals Plus – ER-2A
 - e. Roof Products and Systems – Equipment Rails ER-2B
 - f. Thybar Corporation – TEMS 3
2. Construction:
- a. Minimum 18 gauge, G90 galvanized steel. Fully mitered and welded corners. Integral base plate. 3” Cant style support. All welds prime painted after fabrication. Full-depth internal C-channel reinforcing on 12” centers and 6” spreader channels on alternating 12” centers. 18 Gauge counterflashing factory-installed with tek-screws and neoprene washers. Factory-installed 2’x4” pressure-treated wood nailer.
 - b. Minimum height of 12” above finished roof or as noted.

2.6 MISCELLANEOUS MATERIALS

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

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

- A. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Provide hangers, supports, clamps, and attachments as required to properly support piping from the building structure.
- B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69, MSS SP-89, and Table above. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.
- 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: Provide in pipe hanger or shield for insulated piping.
- E. Pipe Stand Installation:
 1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.

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2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Division 07 Section "Roof Accessories" for curbs.
- F. Provide hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
- G. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
- H. Provide hangers and supports to allow controlled thermal 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. Provide lateral bracing with pipe hangers and supports to prevent swaying.
- J. Provide building attachments within concrete slabs or attach to structural steel. Building attachments may not be used on steel joists unless otherwise indicated. Provide additional attachments at concentrated loads, including valves, flanges, and strainers, 2-1/2" and larger and at changes in direction of piping. Provide concrete inserts before concrete is placed; fasten inserts to forms and provide reinforcing bars through openings at top of inserts.
- K. Load Distribution: Provide hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- L. Pipe Slopes: Provide hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.
- M. Insulated Piping:
 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: Provide thermal-hanger shield insert with clamp sized to match OD of insert.
 - c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
 2. Provide MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
 3. Provide 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. Pipe 1/4" to 3-1/2": 12 inches long and 0.048 inch thick.
 - b. Pipe 4": 12 inches long and 0.06 inch thick.
 - c. Pipe 5" and 6": 18 inches long and 0.06 inch thick.
 - d. Pipe 8" to 14": 24 inches long and 0.075 inch thick.

5. Pipes 8" and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. Thermal-Hanger Shields: Provide with insulation same thickness as piping insulation.

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 bearing surface smooth.
- C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.3 ROOF EQUIPMENT SUPPORTS

- A. Equipment supports must span a minimum of two structural roof members.
- B. No load shall be applied to a cantilever exceeding 12" in length.
- C. Fasten base flange to roof steel or deck with stitch weld or mechanical fastener not exceeding 18" on center in accordance with NRCA specifications.

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/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:
 1. Provide 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 so 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.
- B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.6 PAINTING

- A. Touchup: Unless otherwise indicated clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Provide 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 a minimum dry film thickness of 2.0 mils.
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and immediately apply galvanizing-repair paint. Paint shall comply with ASTM A 780.

3.7 HANGER AND SUPPORT SCHEDULE

- A. Specific hanger and support requirements are 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. Provide hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.
- D. Provide nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- E. Provide copper-plated pipe hangers and copper attachments for copper piping and tubing.
- F. Provide padded hangers for piping that is subject to scratching.
- G. Provide thermal-hanger shield inserts for insulated piping and tubing.
- H. Horizontal-Piping Hangers and Supports: Unless otherwise indicated provide the following:
 - 1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of stationary pipes ½" to 30".
 - 2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F pipes 4" to 14", requiring up to 4" of insulation.
 - 3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes ¾" to 14", requiring clamp flexibility and up to 4 inches of insulation.
 - 4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes ½" to 14" if little or no insulation is required.
 - 5. Pipe Hangers (MSS Type 5): For suspension of pipes ½" to 4", to allow off-center closure for hanger installation before pipe erection.
 - 6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes ¾" to 8".
 - 7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes ½" to 8".

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8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes ½" to 8".
 9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes ½" to 8".
 10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes ½" to 8".
 11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS ½" to 3".
 12. U-Bolts (MSS Type 24): For support of heavy pipes ½" to 14".
 13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
 14. Pipe Saddle Supports (MSS Type 36): For support of pipes 4" to 14", with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
 15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes 4" to 14", with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
 16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes 2-½" to 14" if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
 17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes 1" to 14", from two rods if longitudinal movement caused by expansion and contraction might occur.
 18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes 2-½" to 14", from single rod if horizontal movement caused by expansion and contraction might occur.
 19. Complete Pipe Rolls (MSS Type 44): For support of pipes 2" to 14" if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
 20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes 2" to 14" if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
 21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes 2" to 14" if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.
- I. Vertical-Piping Clamps: Unless otherwise indicated provide the following:
1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers ¾" to 14".
 2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers ¾" to 14" if longer ends are required for riser clamps.
- J. Hanger-Rod Attachments: Unless otherwise indicated provide the following:
1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
 2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
 3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
 4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
 5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.
 6. Flat Plate, Double Nut, and Washer as Detailed on Structural Drawings: For attaching to bar joists. Method of attachment to bar joists must be approved by the structural engineer and joist manufacturer.

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K. Building Attachments: Unless otherwise indicated provide the following:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Flat Plate, Double Nuts, and Washer as Detailed on Structural Drawings: For use under roof installations with bar-joist construction to attach to bottom chord of joist.
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 steel I-beams. Only allowed for open web joists if load does not exceed 50 lbs.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Provide one of the following for indicated loads:
 - a. Light (MSS Type 31): 750 lb.
 - b. Medium (MSS Type 32): 1500 lb.
 - c. Heavy (MSS Type 33): 3000 lb.
13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.
16. For sloping structure, provide clamp with swivel such that required threaded rod is vertical. Bending of threaded rod is not acceptable.

L. Saddles and Shields: Unless otherwise indicated provide the followings:

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.

M. Spring Hangers and Supports: Unless otherwise indicated provide the following:

1. Restraint-Control Devices (MSS Type 47): To control pipe movement.
2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.

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3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
 4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
 5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
 6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
 7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
 8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
 - a. Horizontal (MSS Type 54): Mounted horizontally.
 - b. Vertical (MSS Type 55): Mounted vertically.
 - c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.
- N. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.
- O. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.
- P. Provide powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where indicated in concrete construction.

END OF SECTION 230529

SECTION 230548 - VIBRATION CONTROL FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Provisions of the Contract and of the Contract Documents apply to this Section.

1.2 DEFINITIONS

- A. IBC: International Building Code.
- B. ICC-ES: ICC-Evaluation Service.
- C. OSHPD: Office of Statewide Health Planning & Development for the State of California.
- D. ASCE: American Society of Civil Engineers

1.3 RESPONSIBILITIES:

- A. The manufacturer of vibration isolation systems and devices shall:
 - 1. Determine the sizes and locations of isolators and provide equipment isolation as indicated.
 - 2. Guarantee indicated isolation system deflections.
 - 3. Provide installation instructions and drawings.
 - 4. Certify correctness of installation upon completion.
- B. The Contractor shall cause all vibration isolation systems, including the isolators, and flexible connectors between the isolated equipment and associated piping, ducting, and electrical work to be designed by a manufacturer experienced in this type of work.

1.4 SUBMITTALS

- A. Product Data:
 - 1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
 - 2. Wind-Restraint Details:
 - a. Design Analysis: To support selection and arrangement of wind restraints. Include calculations of combined tensile and shear loads.
 - b. Details: Coordinate vibration isolation details with wind-restraint details required for equipment mounted outdoors.
- B. Coordination Drawings: For areas indicated at 1/4" = 1'0" and where sections are cut on contract drawings, indicate coordination of HVAC piping and equipment with other systems and equipment in the vicinity, include supports and restraints.

- C. Qualification Data: For testing agency.
- D. Shop Drawings:
 - 1. Vibration Isolation Base Details: Detail fabrication, including anchorages, attachments to structure, and to supported equipment. Include auxiliary motor slides and rails, base weights, equipment static loads, power transmission, component misalignment, and cantilever loads.
 - 2. Dimensioned Outline Drawings for Each Scheduled Piece of Equipment: Identify center of gravity.
 - 3. Dimensioned Outline Drawings for Each Scheduled Piece of Equipment: Locate and describe mounting and anchorage provisions.

1.5 QUALITY ASSURANCE

- A. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS

- A. Available Manufacturers:
 - 1. Amber/Booth Company, Inc.
 - 2. B-Line Systems, Inc.
 - 3. Kinetics Noise Control.
 - 4. Mason Industries.
 - 5. Vibration Mountings & Controls, Inc.
 - 6. Vibro-Acoustics, Inc.
- B. Pads: Oil- and water-resistant elastomer or natural rubber, arranged in single or multiple layers, molded with a nonslip pattern and galvanized steel baseplates of sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.
 - 1. Resilient Material: Oil- and water-resistant neoprene.
 - 2. Durometer Rating: Minimum 30.
 - 3. Number of Layers: 1 2 3 or 4.
- C. Mounts: Double-deflection type, with molded, oil-resistant rubber, or neoprene isolator elements with factory-drilled, encapsulated top plate for bolting to equipment and with baseplate for bolting to structure. Color-code or otherwise identify to indicate capacity range.
 - 1. Durometer Rating: Minimum 30.

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2. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
 3. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.
- D. Restrained Mounts: All-directional mountings with wind restraint.
1. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
 2. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.
- E. Spring Isolators: Freestanding, laterally stable, open-spring isolators.
1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 5. Baseplates: Factory drilled for bolting to structure and bonded to ¼" thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig.
 6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.
- F. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with limit-stop restraint.
1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled baseplate bonded to ¼" thick, neoprene or rubber isolator pad attached to baseplate underside; and adjustable equipment mounting and 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.
- G. Housed Spring Mounts: Housed spring isolators.
1. Housing: Ductile-iron or steel housing to provide all-directional restraint.
 2. Base: Factory drilled for bolting to structure.
 3. Snubbers: Vertically adjustable to allow a maximum of ¼" travel up or down before contacting a resilient collar.
- H. Elastomeric Hangers: Double-deflection type, with molded, oil-resistant rubber or neoprene isolator elements bonded to steel housings with threaded connections for hanger rods. Color-code or otherwise identify to indicate capacity range.

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- I. Spring Hangers: 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. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.
- J. Spring Hangers with Vertical-Limit Stop: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression and with a vertical-limit stop.
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.
 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.
- K. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression and with a load stop. Include rod and angle-iron brackets for attaching to equipment.
1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular 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 the 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.
 7. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch movement at start and stop.

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- L. Pipe Riser Resilient Support : All-directional, acoustical pipe anchor consisting of 2 steel tubes separated by a minimum of 1/2-inch- thick, 60-durometer neoprene. Include steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions. Design support for a maximum load on the isolation material of 500 psig and for equal resistance in all directions.
- M. Resilient Pipe Guides: Telescopic arrangement of 2 steel tubes separated by a minimum of 1/2-inch- thick, 60-durometer neoprene. Factory set guide height with a shear pin to allow vertical motion due to pipe expansion and contraction. Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.2 RESTRAINED VIBRATION ISOLATION ROOF-CURB RAILS

- A. Available Manufacturers:
 - 1. Amber/Booth Company, Inc.
 - 2. Kinetics Noise Control.
 - 3. Mason Industries.
 - 4. Vibration Mountings & Controls, Inc.
 - 5. Vibro-Acoustics, Inc.
- B. General Requirements for Restrained Vibration Isolation Roof-Curb Rails: Factory-assembled, fully enclosed, insulated, air- and watertight curb rail designed to resiliently support equipment and to withstand wind forces.
- C. Lower Support Assembly: Formed sheet-metal section containing adjustable and removable steel springs that support upper frame. Upper frame shall provide continuous support for equipment and shall be captive to resiliently resist wind forces. Lower support assembly shall have a means for attaching to building structure and a wood nailer for attaching roof materials, and shall be insulated with a minimum of 2" of rigid, glass-fiber insulation on inside of assembly.
- D. Spring Isolators: Adjustable, restrained spring isolators shall be mounted on 1/4-inch- (6-mm-) thick, elastomeric vibration isolation pads and shall have access ports, for level adjustment, with removable waterproof covers at all isolator locations. Isolators shall be located so they are accessible for adjustment at any time during the life of the installation without interfering with the integrity of the roof.
 - 1. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with wind restraint.
 - a. Housing: Steel with resilient vertical-limit stops and adjustable equipment mounting and leveling bolt.
 - b. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 - c. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 - d. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 - e. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
- E. Snubber Bushings: All-directional, elastomeric snubber bushings at least 1/4 inch (6 mm) thick.

- F. Water Seal: Galvanized sheet metal with EPDM seals at corners, attached to upper support frame, extending down past wood nailer of lower support assembly, and counterflashed over roof materials. Provide counterflashing over EPDM seals to prevent sunlight exposure.

2.3 FACTORY FINISHES

- A. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.
 - 1. Powder coating on springs and housings.
 - 2. All hardware shall be galvanized. Hot-dip-galvanize metal components for exterior use.
 - 3. Bake enamel or powder coat for metal components on isolators for interior use.
 - 4. Color-code or otherwise mark vibration isolation and wind control devices to indicate capacity range.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and equipment to receive vibration isolation and wind-control devices for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. Examine roughing-in of 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 Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.
- B. Strength of Support and Wind Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to resist loads within loading limits.

3.3 VIBRATION-CONTROL DEVICE INSTALLATION

- A. Comply with requirements indicated in the Contract Documents, in codes and ordinances, by Authority Having Jurisdiction, and by Manufacturer, for installation of all devices.

3.4 FIELD QUALITY CONTROL

- A. Perform tests.
- B. Tests:

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 two of each type and size of installed anchors and fasteners.
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.
9. If a device fails test, fix and retest until satisfactory results are achieved then modify all installations of same type to match.

C. Prepare test 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.
- C. Adjust active height of spring isolators.
- D. Adjust restraints to permit free movement of equipment within normal mode of operation.

3.6 VIBRATION ISOLATION SCHEDULE

A. Piping and Conduit

1. All piping and conduit connected to pumps, air handling units, or other pieces of moving equipment which are isolated from the structure by spring type vibration isolators shall be isolated from these units by flexible pipe connectors and shall be suspended on isolation hangers to a point 20 feet away. Refer to Section "Hydronic Piping" for flexible pipe connectors.
2. Provide spring hangers with 1/2" deflection for suspended piping.
3. Provide spring isolators with 1/2" deflection for floor-mounted piping.

B. Ductwork

1. Flexible connectors shall be used for ductwork connections to air handling units. Refer to Section "Metal Duct Accessories." Ductwork shall be suspended with elastomeric hangers for a distance of 20 feet from air handling units.

C. Packaged Rooftop Units / Rooftop Air Handling Units

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1. Provide vibration isolation roof curb rail for rooftop units. Lock out fan and motor assemblies internal isolation provided with rooftop unit. Provide duct connections with flexible duct connectors and pipe connections with flexible piping.
- D. Power Ventilators
1. Provide elastomeric hangers for units suspended from structure above ceiling.
- E. Condensing Units
1. Provide elastomeric neoprene isolator pad with 1/4" deflection located on equipment curb.
- F. Fan-Powered Terminal Units and VRF units.
1. Provide elastomeric hangers for units suspended from structure.
 2. For VRF units, coordinate with MFR for recommended requirements.

END OF SECTION 230548

SECTION 230553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Provisions of the Contract and of the Contract Documents apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Equipment labels.
 - 2. Warning signs and labels.
 - 3. Pipe labels.
 - 4. Duct labels.
 - 5. Valve tags.
 - 6. Warning tags.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.
- C. Valve numbering scheme.
- D. Valve Schedules: For each piping system 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 LABELS

- 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, color-coded laminated plastic. Include contact-type, permanent adhesive.
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 for control devices, dampers, and valves; 4-1/2 by 6 inches for equipment.
- C. Metal Labels for Equipment:
1. Material and Thickness: Brass, 0.032-inch stainless steel, 0.025-inch aluminum, 0.032-inch or anodized aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
 2. Letter Color: White or black.
 3. Background Color: Black or white.
 4. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
 5. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
 6. Fasteners: Stainless-steel rivets or self-tapping screws.
 7. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- D. Plastic Labels for Equipment:
1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8-inch-thick, and having predrilled holes for attachment hardware.
 2. Letter Color: White or black.
 3. Background Color: Black or white.

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4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
 5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
 6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
 7. Fasteners: Stainless-steel rivets or self-tapping screws.
 8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- E. Access Panel and Door Markers: 1/16-inch-thick, engraved laminated plastic, with abbreviated terms and numbers corresponding to identification.
1. Fasteners: Self-tapping, stainless-steel screws or contact-type, permanent adhesive.
- F. Label Content: Include equipment's drawing designation (tag) with unique equipment number as scheduled.

2.2 WARNING SIGNS AND LABELS

- A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8-inch thick, and having predrilled holes for attachment hardware.
- B. Letter Color: White or black.
- C. Background Color: Black or white.
- D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
- E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
- F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
- G. Fasteners: Stainless-steel rivets or self-tapping screws.
- H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- I. Label Content: Include equipment's drawing designation (tag) with unique equipment number as scheduled. Include caution and warning information plus emergency notification instructions.

2.3 PIPE LABELS

- A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction according to ASME A13.1.

- B. Pretensioned Pipe Labels: Pre-coiled, semi-rigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.
- C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
- D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; also include 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: Size letters according to ASME A13.1 for piping.

2.4 DUCT LABELS

- A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8-inch-thick, and having predrilled holes for attachment hardware.
- B. Letter Color: White or black.
- C. Background Color: Black or white.
- D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
- E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
- F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
- G. Fasteners: Stainless-steel rivets or self-tapping screws.
- H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- I. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings; also include duct size and an arrow indicating flow direction.
 - 1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions or as separate unit on each duct label to indicate flow direction.

2.5 VALVE TAGS

- A. Description: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.

1. Tag Material: Brass, 0.032-inch stainless steel, 0.025-inch aluminum, 0.032-inch or anodized aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Fasteners: Brass wire-link chain or beaded chain or S-hook.

B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch 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.

2.6 VALVE SCHEDULES

A. Valve Schedules: For each piping system, on standard-size 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-Schedule Frames: Glazed display frame for removable mounting on masonry walls for each page of valve schedule. Include mounting screws.
2. Frame: Finished hardwood or extruded aluminum.
3. Glazing: ASTM C 1036, Type I, Class 1, Glazing Quality B, 2.5-mm, single-thickness glass.

2.7 WARNING TAGS

A. Description: Preprinted or partially preprinted accident-prevention tags of plasticized card stock with matte finish suitable for writing.

1. Size: 3 by 5-1/4 inches minimum.
2. Fasteners: Reinforced grommet and wire or string.
3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
4. Color: Safety-yellow background with black lettering.

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 GENERAL INSTALLATION REQUIREMENTS

- 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 locations of access panels and doors.
- C. Install identifying devices before installing acoustical ceilings and similar concealment.

3.3 EQUIPMENT LABEL INSTALLATION

- A. Install or permanently fasten labels on each major item of mechanical equipment.
- B. Locate equipment labels where accessible and visible.

3.4 PIPE LABEL INSTALLATION

- A. Pipe Label Locations: 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. 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 and on both sides of through walls, floors, ceilings, and inaccessible 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 along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
 - 7. On piping above removable acoustical ceilings, omit intermediately spaced labels.
- B. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.
- C. Pipe Label Color Schedule:
 - 1. Heating Water Piping: White letters on a safety-green background.
 - 2. Refrigerant Piping: Black letters on a safety-orange background.

3.5 DUCT LABEL INSTALLATION

- A. Install duct markers with permanent adhesive on air ducts in colors complying with ASME A13.1.
- B. Install plastic-laminated or self-adhesive duct labels with permanent adhesive on air ducts in the following color codes:

1. Blue: For cold-air supply ducts.
2. Yellow: For hot-air supply ducts.
3. Green: For exhaust-, outside-, relief-, return-, and mixed-air ducts.

- C. Locate labels near points where ducts enter into and exit from concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system.

3.6 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 HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

- B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:

1. Valve-Tag Size and Shape:
 - a. Refrigerant: 1-1/2 inches, round.
 - b. Hot Water: 1-1/2 inches, round.
 - c. Gas: 1-1/2 inches, round.
2. Valve-Tag Colors:
 - a. Toxic and Corrosive Fluids: Black letters on a safety-orange background.
 - b. Flammable Fluids: Black letters on a safety-yellow background.
 - c. Combustible Fluids: White letters on a safety-brown background.
 - d. Potable and Other Water: White letters on a safety-green background.
 - e. Compressed Air: White letters on a safety-blue background.
 - f. Defined by User: White letters on a safety-purple background, black letters on a safety-white background, white letters on a safety-gray background, and white letters on a safety-black background

3.7 FIRE AND SMOKE DAMPERS

- A. Access points for fire, smoke and fire-smoke dampers shall be permanently identified on the exterior of the duct by a label or sign with letters not less than 1" in height reading: "FIRE/SMOKE DAMPER, SMOKE DAMPER, or FIRE DAMPER."

3.8 VALVE-SCHEDULE INSTALLATION

- A. Mount valve schedule on wall in accessible location in each major equipment room.

3.9 WARNING-TAG INSTALLATION

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

3.10 ADJUSTING

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

END OF SECTION 230553

SECTION 230700 - HVAC INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Provisions of the Contract and of the Contract Documents apply to this Section.

1.2 DEFINITIONS

- A. Outdoor duct and pipe: Duct conveying untreated outside air at ambient temperature and humidity.
- B. Outdoor pipe: Pipe located outside the building insulation envelope.
- C. Supply air duct: Duct conveying air on the discharge side of an air handling unit or fan which will be delivered to a space in a building through a diffuser or connection to the return duct of another unit. Ductwork on the discharge side of a 100% outside air unit is considered to be Supply air duct.
- D. Return air duct: Duct conveying air from a space or plenum that will return to an air handling unit or energy transfer device. The air may be returned to the supply air duct after being conditioned, or it may be exhausted after passing through an energy transfer device. Typical examples of an energy transfer devices are plate heat exchangers, runaround coils, heat pipes, and energy wheels.
- E. Exhaust air duct: Duct conveying air from a space or plenum that will be exhausted from the building without being passed through an energy transfer device.
- F. Plenum: An unoccupied space or void, on the conditioned side of the building insulation and vapor barrier, being used to return conditioned air to the inlet side of a return or exhaust fan either directly or via a duct connection. An example would be a space with air handling light fixtures or openings in the ceiling used to transport air through the ceiling and then to an open duct located above the ceiling in another location.
- G. Indirectly Conditioned Space: A space having no direct conditioning but, due to air movement induced by an exhaust, or return opening, is conditioned by makeup air from an adjacent space. An example would be a small toilet. Boiler rooms, fan rooms, and mechanical rooms do not qualify as indirectly conditioned spaces.
- H. Inside the Building Insulation Envelope: For the purposes of this section, boiler rooms, fan rooms, and mechanical rooms are considered to be OUTSIDE the building insulation envelope.

1.3 SUBMITTALS

- A. Product Data: Identify thermal conductivity, thickness, and jackets (both factory and field applied, if any), for each type of product indicated.
- B. Sustainable Design Submittals: Refer to Division 1 Section "Sustainable Design Requirements."
- C. Shop Drawings: Show fabrication and installation details for the following:
 - 1. Detail application of removable insulation covers.
 - 2. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.

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3. Detail attachment and covering of heat tracing inside insulation.
4. Detail insulation application at pipe expansion joints for each type of insulation.
5. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
6. Detail removable insulation at piping specialties, equipment connections, and access panels.
7. Detail application of field-applied jackets.
8. Detail application at linkages of control devices.
9. Detail field application for each equipment type.

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.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Ship insulation materials in containers marked by manufacturer with type, grade, and maximum use temperature.
- B. Ship Insulated Piping System Components on pallets and wood supports. Securely fasten and protect from damage. Store off the ground and cover with opaque waterproof tarp to protect materials from sunlight and rain.

1.6 COORDINATION

- A. Coordinate size and location of supports, hangers, and insulation shields specified in Section "Hangers and Supports for HVAC Piping and Equipment."
- B. Coordinate clearance requirements with piping Installer for piping insulation, duct Installer for duct insulation, and equipment Installer for equipment insulation.
- C. Maintain clearances required for maintenance.
- D. Coordinate installation and testing of heat tracing.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers:
 1. Mineral-Fiber Insulation:
 - a. CertainTeed Corporation.
 - b. Johns Manville.
 - c. Knauf Insulation.

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- d. Owens Corning.
- 2. Flexible Elastomeric Thermal Insulation:
 - a. Aeroflex USA, Inc.
 - b. Armacell, LLC.
 - c. K-Flex USA.
 - d. Rubatex Corp.
- 3. Removable Insulation Covers:
 - a. Advance Thermal Corp.
- 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. Duct Liner: Refer to specification section "Metal Ducts"
- H. Mineral-Fiber Board: Glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IB, with factory applied FSK Jacket. Meet the requirements of ASTM C 1290, Type III, inorganic glass fibers bonded by a thermosetting resin to maximum service temperature of 250°F.. Faced insulation shall not exceed 25 Flame Spread, 50 Smoke Developed when tested in accordance with ASTM E84.
- I. Semi-Rigid Mineral-Fiber Board: Glass fibers bonded with a thermosetting resin. Comply with ASTM C 1136, Type I, II, III, & IV with factory applied all-service jacket (ASJ) or Type II, IV with factory applied Foil Scrim Kraft (FSK) jacket.
- J. Mineral-Fiber Blanket with Factory Applied FSK Jacket: Meet the requirements of ASTM C 1290, Type III, inorganic glass fibers bonded by a thermosetting resin with a multi-purpose foil-scrim kraft (FSK) jacket to maximum service temperature of 250°F. FSK shall meet the requirements of ASTM C 1136, Type II, when surface burning characteristics are determined in accordance with ASTM E 84 with the foil surface of the material exposed to the flame as it is in the final composite. Composite (insulation, facing and adhesive) shall not exceed 25 Flame Spread, 50 Smoke Developed when tested in accordance with ASTM E 84. Insulation properties shall be as follows:
 - 1. Thickness: 1-1/2"
 - a. Density: 0.75 pcf
 - b. Minimum uncompressed R value: 5.1
 - c. Minimum installed R value assuming 25% compression: 4.2
 - 2. Thickness: 2"
 - a. Density: 1.0 pcf
 - b. Minimum uncompressed R value: 7.4
 - c. Minimum installed R value assuming 25% compression: 6.0

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3. Alternate to 2" 1.0 pcf: Thickness: 2.2"
 - a. Density: 0.75 pcf
 - b. Minimum uncompressed R value: 7.4
 - c. Minimum installed R value assuming 25% compression: 6.0
 4. Thickness: 3"
 - a. Density: 0.75 pcf
 - b. Minimum uncompressed R value: 10.2
 - c. Minimum installed R value assuming 25% compression: 8.3
- K. Mineral-Fiber Pipe Insulation: Glass fibers bonded with a thermosetting resin complying with the following:
1. Preformed Pipe Insulation: Comply with ASTM C 547, Type 1, with factory-applied, all-purpose, vapor-retarder jacket.
 2. Semi-Rigid Mineral-Fiber Board: Glass fibers bonded with a thermosetting resin. Comply with ASTM C 1136, Type I, II, III, IV with factory applied all-service jacket (ASJ) or Type II, IV with factory applied Foil Scrim Kraft (FSK) jacket.
 3. Blanket Insulation: Comply with ASTM C 553, Type II, without facing.
 4. Fire-Resistant Adhesive: Comply with MIL-A-3316C in the following classes and grades:
 - a. Class 1, Grade A for bonding glass cloth and tape to unfaced glass-fiber insulation, for sealing edges of glass-fiber insulation, and for bonding lagging cloth to unfaced glass-fiber insulation.
 - b. Class 2, Grade A for bonding glass-fiber insulation to metal surfaces.
 5. Vapor-Retarder Mastics: Fire- and water-resistant, vapor-retarder mastic for indoor applications. Comply with MIL-C-19565C, Type II.
 6. Mineral-Fiber Insulating Cements: Comply with ASTM C 195.
 7. Expanded or Exfoliated Vermiculite Insulating Cements: Comply with ASTM C 196.
 8. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449/C 449M.
- L. 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. Adhesive: As recommended by insulation material manufacturer.
 2. Ultraviolet-Protective Coating: As recommended by insulation manufacturer.
- M. Cellular-Glass: Inorganic, foamed or cellulated glass, annealed, rigid, hermetically sealed cells, incombustible preformed pipe Insulation, with jacket. Comply with ASTM C 552, Type II, Class 2.
- N. Prefabricated Thermal Insulating Fitting Covers: Comply with ASTM C 450 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.
- 2.2 FIELD-APPLIED JACKETS
- A. General: ASTM C 921, Type 1, unless otherwise indicated.
 - B. Glass Cloth: Woven glass-fiber fabric, plain weave, minimum 8 ounces per square yard.
 - C. Foil and Paper Jacket: Laminated, glass-fiber-reinforced, flame-retardant kraft paper and aluminum foil.

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- D. PVC Jacket: High-impact, ultraviolet-resistant PVC; 20 mils thick; roll stock ready for shop or field cutting and forming.
 - 1. Adhesive: As recommended by insulation material manufacturer.
 - 2. PVC Duct Jacket Color: White or gray.
 - 3. PVC Pipe Jacket Color: Color-code piping jackets based on materials contained within the piping system.
- E. Aluminum Jacket: Deep corrugated sheets manufactured from aluminum alloy complying with ASTM B 209, and having an integrally bonded moisture barrier over entire surface in contact with insulation. Factory cut and rolled to indicated sizes. Comply with ASTM B 209, 3003 alloy, H-14 temper.
 - 1. Finish and Thickness: Stucco-embossed finish, 0.016 inch thick.
 - 2. Moisture Barrier: 1-mil- thick, heat-bonded polyethylene and kraft paper.
 - 3. Elbows: Preformed, 45- and 90-degree, short- and long-radius elbows; same material, finish, and thickness as jacket.
- F. Heavy PVC Pipe Fitting Covers: Factory-fabricated fitting covers manufactured from 30-mil-thick, high-impact, ultraviolet-resistant PVC.
 - 1. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories for the disabled.
 - 2. Adhesive: As recommended by insulation material manufacturer.
- G. Standard PVC Pipe Fitting Covers: Factory-fabricated fitting covers manufactured from 20-mil- thick, high-impact, ultraviolet-resistant PVC.
 - 1. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories for the disabled.
 - 2. Adhesive: As recommended by insulation material manufacturer.

2.3 REMOVABLE INSULATION COVERS

- A. Pre-manufactured easily removable insulation cover/blanket intended for insulation of equipment and devices requiring periodic maintenance.

2.4 ACCESSORIES AND ATTACHMENTS

- A. Glass Cloth and Tape: Comply with MIL-C-20079H, Type I for cloth and Type II for tape. Woven glass-fiber fabrics, plain weave, presized a minimum of 8 oz./sq. yd..
 - 1. Tape Width: 4 inches.
- B. Bands: 3/4 inch wide, in one of the following materials compatible with jacket:
 - 1. Stainless Steel: ASTM A 666, Type 304; 0.020 inch thick.
 - 2. Galvanized Steel: 0.005 inch thick.
 - 3. Aluminum: 0.007 inch thick.
 - 4. Brass: 0.010 inch thick.
 - 5. Nickel-Copper Alloy: 0.005 inch thick.
- C. Wire: 0.080-inch, nickel-copper alloy; 0.062-inch, soft-annealed, stainless steel; or 0.062-inch, soft-annealed, galvanized steel.

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- D. Weld-Attached Anchor Pins and Washers: Copper-coated steel pin for capacitor-discharge welding and galvanized speed washer. Pin length sufficient for insulation thickness indicated.
 - 1. Welded Pin Holding Capacity: 100 lb for direct pull perpendicular to the attached surface.
- E. Adhesive-Attached Anchor Pins and Speed Washers: Galvanized steel plate, pin, and washer manufactured for attachment to duct, pipe, plenum and breeching with adhesive. Pin length sufficient for insulation thickness indicated.
 - 1. Adhesive: Recommended by the anchor pin manufacturer as appropriate for surface temperatures of ducts, pipes, plenums, and breechings; and to achieve a holding capacity of 100 lb. for direct pull perpendicular to the adhered surface.
- F. Self-Adhesive Anchor Pins and Speed Washers: Galvanized steel plate, pin, and washer manufactured for attachment to duct, pipe, and plenum with adhesive. Pin length sufficient for insulation thickness indicated.

2.5 VAPOR RETARDERS

- A. Mastics: Materials that are compatible with insulation materials, jackets, and substrates.

2.6 REMOVABLE INSULATION COVERS

- A. Pre-manufactured easily removable insulation cover/blanket intended for insulation of equipment and devices requiring periodic maintenance.

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.
- B. 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.

3.3 GENERAL APPLICATION REQUIREMENTS

- A. Apply insulation materials, accessories, and finishes according to the manufacturer's written instructions; with smooth, straight, and even surfaces; and free of voids throughout the length of ducts, piping, and fittings.
- B. Refer to schedules at the end of this Section for materials, forms, jackets, and thickness required for each system.
- C. Use accessories compatible with insulation materials and suitable for the service. Use accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Apply multiple layers of insulation with longitudinal and end seams staggered.

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- E. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- F. Seal joints and seams with vapor-retarder mastic on insulation indicated to receive a vapor retarder.
- G. Keep insulation materials dry at all times. Insulation that becomes wet or is otherwise damaged beyond repair, shall be removed immediately and replaced. Replacement material and installation shall be in accordance with these specifications.
- H. Apply insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by the insulation material manufacturer.
- I. Apply insulation with the minimum number of joints practical.
- J. Apply insulation over fittings, valves, and specialties, with continuous thermal and vapor-retarder integrity, unless otherwise indicated.
- K. Refer to special instructions for applying insulation over fittings, valves, and specialties.
- L. Hangers and Anchors: Where vapor retarder is indicated, seal penetrations in insulation at hangers, supports, anchors, and other projections with vapor-retarder mastic.
 - 1. Apply insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor retarders are indicated, extend insulation on anchor legs at least 12 inches from point of attachment to pipe and taper insulation ends. Seal tapered ends with a compound recommended by the insulation material manufacturer to maintain vapor retarder.
 - 3. Install insert materials and apply insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by the insulation material manufacturer.
 - 4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect the jacket from tear or puncture by the hanger, support, and shield.
- M. Insulation Terminations: For insulation application where vapor retarders are indicated, seal ends with a compound recommended by the insulation material manufacturer to maintain vapor retarder.
- N. Apply insulation with integral jackets as follows:
 - 1. Pull jacket tight and smooth.
 - 2. Joints and Seams: Cover with tape and vapor retarder to maintain vapor seal.
 - 3. Vapor-Retarder Mastics: Where vapor retarders are indicated, apply mastic on seams and joints and at ends adjacent to duct flanges, pipe joints, and fittings.
- O. Cut insulation according to manufacturer's written instructions to prevent compressing insulation to less than 75 percent of its nominal thickness.
- P. Install vapor-retarder mastic on ducts, pipes, plenums, and equipment.
 - 1. Ducts, pipes, plenums, and equipment with Vapor Retarders: Overlap insulation facing at seams and seal with vapor-retarder mastic and pressure-sensitive tape having same facing as insulation. Repair punctures, tears, and penetrations with tape and mastic to maintain vapor-retarder seal.
 - 2. Ducts, pipes, plenums, and equipment without Vapor Retarders: Overlap insulation facing at seams and secure with outward clinching staples and pressure-sensitive tape having same facing as insulation.

- Q. Roof Penetrations: Apply insulation for interior applications to a point even with top of roof flashing.
 - 1. Seal penetrations with vapor-retarder mastic.
 - 2. Apply insulation for exterior applications tightly joined to interior insulation ends.
 - 3. Seal insulation to roof flashing with vapor-retarder mastic.
- R. Interior Wall and Partition Penetrations: Apply insulation continuously through walls and partitions, except fire-rated walls and partitions.
- S. Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire/smoke damper sleeves for fire-rated wall and partition penetrations.
- T. Floor Penetrations: Terminate insulation at underside of floor assembly and at floor support at top of floor.
 - 1. For insulation indicated to have vapor retarders, taper termination and seal insulation ends with vapor-retarder mastic.

3.4 MINERAL-FIBER INSULATION APPLICATION

- A. Blanket Applications for Ducts, Pipes, and Plenums: Secure blanket insulation with adhesive, and anchor pins with speed washers.
 - 1. Apply adhesives according to manufacturer's recommended coverage rates per square foot, for 100 percent coverage of duct, pipe, and plenum surfaces.
 - 2. Apply adhesive to entire circumference of ducts & pipes and to all surfaces of fittings and transitions. Adhesive may be omitted from the top of horizontal rectangular ducts.
 - 3. Install anchor pins and speed washers on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. On duct sides with dimensions 18 inches and smaller, along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
 - b. On duct sides with dimensions larger than 18 inches. Space 16 inches o.c. each way, and 3 inches maximum from insulation joints. Apply additional pins and clips to hold insulation tightly against surface at cross bracing.
 - c. Anchor pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not compress insulation to less than 75% of its original thickness during installation.
 - 4. Install anchor pins and speed washers on sides, top, and bottom of horizontal pipes.
 - 5. Impale insulation over anchors and attach speed washers.
 - 6. Cut excess portion of pins extending beyond speed washers. Cover exposed pins and washers with tape matching insulation facing.
 - 7. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation segment with 1/2-inch staples, 1-inch o.c., and cover with pressure-sensitive tape having same facing as insulation.
 - 8. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. Secure with steel band at end joints and spaced a maximum of 18 inches o.c.
 - 9. Apply insulation on rectangular duct elbows, pipe fittings, and transitions with a full insulation segment for each surface. Apply insulation on round and flat-oval duct elbows, and pipe elbows, with individually mitered gores cut to fit the elbow.

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10. Insulate duct and pipe stiffeners, hangers, and flanges that protrude beyond the insulation surface with 6-inch- wide strips of the same material as insulation. Secure on alternating sides of stiffener, hanger, and flange with anchor pins spaced 6 inches o.c.
 11. Apply vapor-retarder mastic to open joints, breaks, and punctures for insulation indicated to receive vapor retarder.
- B. Board Applications for Ducts, Plenums, & Equipment: Secure board insulation with adhesive and anchor pins and speed washers.
1. Apply adhesives according to manufacturer's recommended coverage rates per square foot, for 100 percent coverage of duct, plenum, & equipment surfaces.
 2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings, transitions, and equipment. Adhesive may be omitted from top surface of horizontal rectangular ducts.
 3. Space anchor pins as follows:
 - a. On duct & equipment sides with dimensions 18 inches and smaller, along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
 - b. On duct & equipment sides with dimensions larger than 18 inches. Space 16 inches o.c. each way, and 3 inches maximum from insulation joints. Apply additional pins and clips to hold insulation tightly against surface at bracing.
 - c. Anchor pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not compress insulation to less than 75% of its original thickness during installation.
 4. Cut excess portion of pins extending beyond speed washers. Cover exposed pins and washers with tape matching insulation facing.
 5. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation segment with 1/2-inch staples, 1-inch o.c., and cover with pressure-sensitive tape having same facing as insulation.
 6. Apply insulation on rectangular duct elbows and transitions with a full insulation segment for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Apply insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
 7. Insulate duct and equipment stiffeners, hangers, and flanges that protrude beyond the insulation surface with 6" wide strips of the insulating materia. Secure on alternating sides of stiffener, hanger, and flange with anchor pins spaced 6 inches o.c.
 8. Apply vapor-retarder mastic to open joints, breaks, and punctures for insulation indicated to receive vapor retarder.

3.5 FLEXIBLE ELASTOMERIC THERMAL INSULATION APPLICATION

- A. Apply insulation to ducts, plenums, and equipment as follows:
1. Follow the manufacturer's written instructions for applying insulation.
 2. Seal longitudinal seams and end joints with manufacturer's recommended adhesive. Cement to avoid openings in insulation that will allow passage of air to the duct, plenum, and equipment surface.

3.6 FIELD-APPLIED JACKET APPLICATION

- A. Apply glass-cloth jacket, where indicated, directly over bare insulation or insulation with factory-applied jackets.
 - 1. Apply jacket smooth and tight to surface with 2-inch overlap at seams and joints.
 - 2. Embed glass cloth between two 0.062-inch- thick coats of jacket manufacturer's recommended adhesive.
 - 3. Completely encapsulate insulation with jacket, leaving no exposed raw insulation.

3.7 FINISHES

- A. Glass-Cloth Jacketed Insulation: Paint insulation finished with glass-cloth jacket as specified in Division 9 Section "Paints."
- B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.
- C. Color: Final color shall be as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

3.8 DIFFUSER APPLICATIONS

- A. Insulate exposed metal surfaces on top of all supply diffusers. Where diffusers are mounted in a metal pan insulate the top of the metal pan.
 - 1. Material: Mineral-Fiber Blanket Thermal Insulation with Factory Applied FSK Jacket.
 - 2. Thickness: 1 inch.
 - 3. Vapor Retarder Required: Yes.

3.9 APPLICATIONS

- A. Insulation materials and thickness are specified at the end of this Section.
- B. Insulate all ductwork, pipe and equipment:
 - 1. Insulate ductwork in accordance with the application schedule(s) below.
 - 2. Exceptions: Unless otherwise indicated, do not apply insulation to the following systems, materials, and equipment:
 - a. Vibration-control devices.
 - b. Testing agency labels and stamps.
 - c. Nameplates and data plates.
 - d. Manholes.
 - e. Handholes.
 - f. Cleanouts.
 - g. Plastic condensate drain piping.
 - h. Pipe-mounted condensate sensors.
 - i. Return ductwork inside the building insulation envelope.
 - j. Indoor exposed return air ductwork.
 - k. Exhaust ductwork.
 - 1) Exception: Duct beginning 18" upstream of backdraft damper and continuing to building envelope insulation.
 - l. Metal ducts with duct liner.
 - m. Factory-insulated flexible ducts.
 - n. Factory-insulated plenums, casings, terminal boxes, and filter boxes and sections.

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- o. Flexible connectors.
- p. Access panels and doors in air-distribution systems.

3.10 INDOOR APPLICATION SCHEDULE

- A. Service: Condensate drain piping except plastic.
 - 1. Insulation Material: Mineral fiber preformed pipe insulation.
 - 2. Insulation Thickness: 1"
 - 3. Vapor Retarder Required: Yes.
 - 4. Finish: Finished Spaces = Painted, concealed = none.
- B. Service: Heating hot-water supply and return.
 - 1. Insulation Material: Mineral fiber preformed pipe insulation.
 - 2. Insulation Thickness: Apply the following insulation thicknesses:
 - a. Steel, Copper, & PVC Pipe, Up to 1.5" diameter: 1-1/2 inches.
 - b. Steel, Copper, & PVC Pipe, 2" diameter & up: 2 inches.
 - 3. Vapor Retarder Required: No.
 - 4. Finish: Finished Spaces = Painted, concealed = none.
- C. Refrigerant Suction and Hot-Gas Piping/Tubing:
 - 1. Insulation Material and Thickness:
 - a. Cellular Glass: 1-1/2 inches thick.
 - b. Flexible Elastomeric: 1 inch thick.
 - c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
- D. Service: Unless otherwise indicated provide the following:
 - 1. Concealed Ducts and Plenums:
 - a. Material: Mineral-Fiber Blanket.
 - b. Thickness: 2 inches.
 - c. Vapor Retarder Required: Yes.
 - 2. Ducts and Plenums in Finished Spaces:
 - a. Material: Mineral-Fiber Board.
 - b. Thickness: 1-1/2 inches.
 - c. Field-Applied Jacket: Glass cloth.
 - d. Vapor Retarder Required: Yes.
 - e. Paint: Color as selected by architect. Refer to section "Painting".
- E. Service: Supply-air ducts, concealed and within the building insulation envelope.
 - 1. Material: Mineral-Fiber Blanket Thermal Insulation with Factory Applied FSK Jacket.
 - 2. Thickness: 1-1/2 inches.
 - 3. Vapor Retarder Required: Yes.
- F. Service: Outside-air ducts, concealed and within the building insulation envelope.
 - 1. Material: Mineral-Fiber Blanket Thermal Insulation with Factory Applied FSK Jacket.
 - 2. Thickness: 1-1/2 inches.
 - 3. Vapor Retarder Required: Yes.
- G. Service: Round and flat oval, supply-air ducts, exposed.

1. Refer to section "Metal Ducts"
 - H. Service: Round and flat oval, outside-air ducts, exposed.
 1. Refer to section "Metal Ducts"
 - I. Service: Rectangular, supply-air ducts, in Finished Spaces.
 1. Material: Mineral-Fiber Board Thermal Insulation, Unfaced
 2. Thickness: 1-1/2 inches.
 3. Field-Applied Jacket: Glass cloth.
 4. Vapor Retarder Required: Yes.
 5. Paint: Color as selected by architect. Refer to section "Painting".
 - J. Service: Rectangular, outside-air ducts, in Finished Spaces.
 1. Material: Mineral-Fiber Board Thermal Insulation, Unfaced
 2. Thickness: 2 inches
 3. Field-Applied Jacket: Glass cloth.
 4. Vapor Retarder Required: Yes.
 5. Paint: Color as selected by architect. Refer to section "Painting".
- 3.11 OUTDOOR APPLICATION SCHEDULE
- A. Insulation shall be applied after heat tracing and temperature sensors are in place and have been tested.
 - B. Refrigerant Suction and Hot-Gas Piping:
 1. Insulation Material and Thickness:
 - a. Cellular Glass: 2 inches thick.
 - b. Flexible Elastomeric: 2 inches thick.
 - c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches thick.
 2. Finish: Two coats of UV coating or mastic protectant recommended by the insulation manufacturer or outdoor aluminum jacket.

END OF SECTION 230700

SECTION 230900 – BUILDING AUTOMATION SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Provisions of the Contract and of the Contract Documents apply to this Section.

1.2 SUMMARY

- A. This Section includes control equipment for HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory-wired controls.
- B. Related Sections include the following:
 - 1. Division 23 Section "Meters and Gages for HVAC Piping" for measuring equipment that relates to this Section.
 - 2. Division 23 Section "Sequence of Control" for requirements that relate to this Section.
 - 3. Division 28 Sections for additional conduit requirements for all electronic safety and security systems specified under Division 28.
- C. Work Under Other Sections:
 - 1. All wells, valves, taps, dampers, flow stations, etc. furnished by the BAS manufacturer shall be installed under other Division 23 sections.
 - 2. The following shall be provided under Division 23 specifications sections:
 - a. 120V power to BAS panels and devices with circuits indicated on the drawings. See paragraph "Coordination" below.
 - b. Wiring of power feeds to disconnect switches and starters.
 - c. Wiring from disconnect switches and starters to electric motors.
 - d. Wiring of any remote start/stop switches and manual or automatic motor speed control devices not furnished under this section of the specifications.

1.3 DEFINITIONS

- A. BAS: Building Automation System.
- B. DDC: Direct digital control.
- C. I/O: Input/output.
- D. IT: Information Technology.
- E. IS: Information Systems.
- F. LAN: Local Area Network.

- G. MS/TP: Master-slave/token-passing
- H. NAC: Network area controllers.
- I. PC: Personal computer.
- J. PID: Proportional plus integral plus derivative.
- K. PPM: Parts per million.
- L. RTD: Resistance temperature detector.

1.4 SYSTEM PERFORMANCE

- A. Comply with the following performance requirements:
 - 1. Graphic Display: Display graphic with minimum 20 dynamic points with current data within 10 seconds.
 - 2. Graphic Refresh: Update graphic with minimum 20 dynamic points with current data within 8 seconds.
 - 3. Object Command: Reaction time of less than two seconds between operator command of a binary object and device reaction.
 - 4. Object Scan: Transmit change of state and change of analog values to control units or workstation within six seconds.
 - 5. Alarm Response Time: Annunciate alarm at workstation within 45 seconds. Multiple workstations must receive alarms within five seconds of each other.
 - 6. Program Execution Frequency: Run capability of applications as often as five seconds, but selected consistent with mechanical process under control.
 - 7. Performance: Programmable controllers shall execute DDC PID control loops, and scan and update process values and outputs at least once per second.
 - 8. Reporting Accuracy and Stability of Control: Report values and maintain measured variables within tolerances as follows:
 - a. Water Temperature: Plus or minus 1 deg F.
 - b. Water Flow: Plus or minus 5 percent of full scale.
 - c. Water Pressure: Plus or minus 2 percent of full scale.
 - d. Space Temperature: Plus or minus 1 deg F.
 - e. Ducted Air Temperature: Plus or minus 1 deg F.
 - f. Outside Air Temperature: Plus or minus 2 deg F.
 - g. Dew Point Temperature: Plus or minus 3 deg F.
 - h. Temperature Differential: Plus or minus 0.25 deg F.
 - i. Relative Humidity: Plus or minus 5 percent.
 - j. Airflow (Measuring Stations): Plus or minus 5 percent of full scale.
 - k. Airflow (Terminal): Plus or minus 10 percent of full scale.
 - l. Air Pressure (Space): Plus or minus 0.01-inch wg.
 - m. Air Pressure (Ducts): Plus or minus 0.1-inch wg.
 - n. Carbon Dioxide: Plus or minus 50 ppm.
 - o. Carbon Monoxide: Plus or minus 2 ppm.
 - p. Electrical: Plus or minus 5 percent of reading.

1.5 SYSTEM DESCRIPTION

- A. Control system consists of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, and accessories to control mechanical systems.
- B. Control system includes interface to the following:
 - 1. Division 28 sections on Electronic Safety and Security Systems. Provide interface outputs for selective annunciation and monitoring (i.e. alarm status).
 - 2. Building lighting control system specified in Division 26 Section "Lighting Control Devices."
 - 3. Fire alarm system specified in Division 28 Section "Fire Alarm and Smoke Detection System."

1.6 WARRANTY

- A. Provide all services, materials and equipment necessary for the successful operation of the entire BAS system for a period of one year beginning on the date of Substantial Completion.
- B. Services, materials, and equipment shall include but not be limited to:
 - 1. The adjustment, required testing, and repair of the system including all computer equipment, transmission lines, transmission equipment, sensors and control devices.
 - 2. On-line support services shall be provided as follows:
 - a. The local BAS representative shall have the capability to monitor and control the facility's building automation system via a dialup or internet connection. This connection to the facility shall be made within 2 hours of the time a problem is reported.
 - b. If the problem is not resolved by local support, the national office of the building automation system manufacturer, having the same dialup capability, shall also attempt to solve the problem online. If the problem cannot be resolved with on-line support, the BAS representative shall dispatch the appropriate personnel to the job site to resolve the problem within 4 hours of the time that the problem is reported.
 - c. This coverage shall include normal business hours, after business hours, weekends and holidays.

1.7 SUBMITTALS

- A. Pre-submittal meeting: The Contractor performing work under this Section of the specifications shall attend a meeting for the purpose of coordinating the control system with major pieces of equipment including Packaged Rooftop Units and Computer Room Air Conditioners. The meeting shall be held on the project site in the contractor's trailer or other location acceptable to the Contractor. The Contractor shall be responsible for arranging the meeting. Submittals shall be essentially complete at the time of the meeting so detailed coordination items can be discussed.
- B. Submit ten (10) complete sets of documentation in the following phased delivery schedule:
 - 1. Schedule of dampers including size, leakage, and flow characteristics.

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2. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated. Include each control device labeled with setting or adjustable range of control.
3. 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. Include the following:
 - a. System schematics, including:
 - 1) Written sequences of operation
 - 2) Listing of connected data points, including connected control unit and input device.
 - a) point names
 - b) point addresses
 - 3) Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.
 - 4) Details of control panel faces, including controls, instruments, and labeling.
 - 5) Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices.
 - 6) Trunk cable schematic showing programmable control unit locations and trunk data conductors.
 - 7) System graphics indicating monitored systems, data (connected and calculated) point addresses, and operator notations.
 - 8) System configuration showing peripheral devices, batteries, power supplies, diagrams, modems, and interconnections.
- C. Maintenance Data: For systems to include in maintenance manuals specified in Division 1. Include the following:
 1. Maintenance instructions and lists of spare parts for each type of control device and compressed-air station.
 2. Interconnection wiring diagrams with identified and numbered system components and devices.
 3. Keyboard illustrations and step-by-step procedures indexed for each operator function.
 4. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
 5. Calibration records and list of set points.
- D. Project Record Documents: Record actual locations of control components, including control units, thermostats, and sensors. Revise Shop Drawings to reflect actual installation and operating sequences.
- E. Upon project completion, submit operation and maintenance manuals, consisting of the following:
 1. Index sheet listing contents in alphabetical order.
 2. Manufacturer's equipment parts list of all functional components of the system.
 3. CD-ROM of system schematics including wiring diagrams.
 4. Sequence of operations
 5. As-built interconnection wiring diagrams.
 6. Operator's manual.
 7. Trunk cable schematic showing remote electronic panel locations and all trunk data.

8. List of connected data points, including panels to which they are connected and input device (sensors, thermostat, etc.)
9. Software and firmware operational documentation. Include the following:
 - a. Software operating and upgrade manuals.
 - b. Program software backup: On a magnetic media or compact disc, complete with data files.
 - c. Device address list.
 - d. Printout of software application and graphic screens.
 - e. Software license required by and installed for DDC workstations and control systems.
10. Software Upgrade Kit: For Owner to use in modifying software to suit future power system revisions or monitoring and control revisions.
11. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

- F. Submit product data sheets for airflow measuring devices indicating minimum placement requirements, sensor density, sensor distribution, and installed accuracy to the host control system. Submit a schedule of airflow measuring devices indicating compliance with specified accuracy at minimum and maximum airflow rates. Submit installation, operation and maintenance documentation.

1.8 QUALITY ASSURANCE

- A. The BAS system shall be designed and installed, commissioned, and serviced by a manufacturer's authorized installer.
- B. Manufacturer Qualifications: A firm experienced in manufacturing automatic temperature-control systems similar to those indicated for this Project and with a record of successful in-service performance.
- C. All materials and equipment used shall be standard components, regularly manufactured for this and/or other systems and not custom designed specially for this project.
- 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. Electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Section 15, governing radio frequency electromagnetic interference and shall be so labeled.
- F. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilation Systems."

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory-mounted on equipment, arrange for shipping of control devices to equipment manufacturer.

- B. System Software: Update to latest version of software at Project completion.

1.10 COORDINATION

- A. Control Wiring: The BAS manufacturer shall be responsible for all BAS and temperature control wiring for a complete and operable system. All wire and cable shall be plenum-rated and shall be in accordance with Division 26 specification sections and all local, state and national codes and ordinances.
- B. Where plenum-rated BAS cable is routed in concealed, accessible spaces, the cable may be run in the cable trays or in J-Hooks provided under this section of the specifications. Where plenum-rated BAS cable is routed in exposed or inaccessible areas, it shall be run conduit provided under this section of the specifications.
- C. Power Wiring:
 - 1. Power wiring indicated (device and circuit designation indicated) on the drawings shall be provided under Division 26.
 - 2. The BAS manufacturer shall be responsible for power wiring not indicated (device or circuit designation not indicated) on the Drawings. It shall be the BAS manufacturer's responsibility to review the Contract Documents to determine the extent of power wiring included in Division 26 and to provide additional power wiring as required. Work shall be in accordance with Division 26 specifications and all local, state and national codes and ordinances.
 - 3. Where the contractor performing work under this section requires an additional circuit for power wiring to a device or panel under paragraph 2 above, an RFI shall be issued requesting approval to use an available circuit in the nearest panel. Once approval is granted, all wiring and conduit from the breaker to the device or panel shall be provided under this section of the specifications.
- D. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation. All conduits shall be concealed within walls and above ceilings unless indicated otherwise.
- E. Coordinate installation of conduit to avoid cutting of finished surfaces.
- F. Coordinate equipment with Division 28 Section "Common Work Results for Electronic Safety and Security" for building security control detection system and selective annunciation and monitoring only (i.e. 'status alarms').
- G. Coordinate equipment with Division 26 Section "Lighting Control Devices" to achieve compatibility with equipment that interfaces with that system.
- H. Coordinate equipment with Division 28 Section "Fire Alarm and Smoke Detection System" to achieve compatibility with equipment that interfaces with that system.
- I. Coordinate supply of conditioned electrical branch circuits for control units and operator workstation.

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- J. Coordinate equipment with Division 26 Section "Panelboards" to achieve compatibility with starter coils and annunciation devices.
- K. Coordinate equipment with Division 26 Section "Switchboards" to achieve compatibility with power monitoring and metering devices in that equipment.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers:
 - 1. Trane.

2.2 ARCHITECTURE/COMMUNICATION

- A. General Overview: The existing building currently has a Trane system, where the new addition will interface with this system so a single head end graphics for the existing and new addition is developed. The existing Trane system shall be provided with all software upgrades as necessary for new addition interface. If any modifications are made to the existing control systems, written confirmation shall be obtained from the performance contractor prior to making those modifications. Outside air sensors are not required if the existing building already has them and information can be gained for associated sequences of control. **No wireless controls should be used for new controls provided, regardless of existing conditions without specific expectation from the Owner.**
- B. This project shall be comprised of a high speed Ethernet network utilizing BACnet/IP communications between System Controllers and Workstations. Communications between System Controllers and sub-networks of Custom Application Controllers and/or Application Specific Controllers shall utilize LonTalk (FTT10) or BACnet MSTP (RS485) communications.
- C. Each System Controller shall perform communications to a network of Custom Application and Application Specific Controllers using BACnet/MSTP (RS485) or LonTalk (FTT10) as defined by the BACnet or LonTalk standard.
 - 1. Each System Controller shall function as a BACnet Router to each unit controller providing a unique BACnet Device ID for all BACnet/MSTP controllers within the system.
 - 2. All LonTalk Unit Controllers shall conform to the LonTalk standard and conform to a LonMark Profile.
 - 3. Points within LonTalk unit controllers shall be exposed as standard BACnet points within the System Controller without need for manual intervention by an operator.
- D. The Owner will provide all communication media, connectors, repeaters, network switches, and routers necessary for the high speed Ethernet network. An active Ethernet port will be provided adjacent to each System Controller and operator interface (PC) for connection to this high speed Ethernet network.

- E. All values within the system (i.e. schedules, datalogs, points, software variables, custom program variables) shall be readable and controllable (where appropriate) by any System Controller or BACnet Workstation on the communications network via BACnet.

2.3 OPERATOR INTERFACE

A. Operator Interface

- a. The operator interface shall be accessible via a web browser.
- b. The operator interface shall support the following Internet web browsers:
 - 1) Internet Explorer 8.0+
 - 2) Firefox 4.0+
 - 3) Chrome 10.0+
- c. The operator interface shall support the following mobile web browsers:
 - 1) iOS (iPad/iPhone) V4.0+
 - 2) Android (Tablet) V4.0+
 - 3) Android (Phone) V2.3+
- d. System Security
 - 1) Each operator shall be required to login to the system with a user name and password in order to view, edit, add, or delete data.
 - 2) User Profiles shall restrict the user to only the objects, applications, and system functions as assigned by the system administrator.
 - 3) Each operator shall be allowed to change their user password
 - 4) The System Administrator shall be able to manage the security for all other users
 - 5) The system shall include pre-defined "roles" that allow a system administrator to quickly assign permissions to a user.
 - 6) User logon/logoff attempts shall be recorded.
 - 7) The system shall protect itself from unauthorized use by automatically logging off following the last keystroke. The delay time shall be user definable.
 - 8) All system security data shall be stored in an encrypted format.
- e. Database
 - 1) Database Save. A system operator with the proper password clearance shall be able to archive the database on the designated operator interface PC.
 - 2) Database Restore. The system operator shall also be able to clear a panel database and manually initiate a download of a specified database to any panel in the system.
- f. On-Line Help and Training
 - 1) Provide a context sensitive, on line help system to assist the operator in operation and configuration of the system.
 - 2) On-line help shall be available for all system functions and shall provide the relevant data for each particular screen.
- g. System Diagnostics
 - 1) The system shall automatically monitor the operation of all network connections, building management panels, and controllers.
 - 2) The failure of any device shall be annunciated to the operators.
- h. Equipment & Application Pages
 - 1) The operator interface shall include standard pages for all equipment and applications. These pages shall allow an operator to obtain information relevant to the operation of the equipment and/or application, including:
 - a) Animated Equipment Graphics for each major piece of equipment and floor plan in the System. This includes:

- (1) Each Air Handler, VAV Terminal, CRAC unit. These graphics shall show all points dynamically.
 - (2) Animation capabilities shall include the ability to show a sequence of images reflecting the position of analog outputs, such as valve or damper positions. Graphics shall be capable of launching other web pages.
- b) Alarms relevant to the equipment or application without requiring a user to navigate to an alarm page and perform a filter.
- c) Historical Data (As defined in Automatic Trend Log section below) for the equipment or application without requiring a user to navigate to a data log page and perform a filter.
- i. System Graphics. Operator interface shall be graphically based and shall include at least one graphic per piece of equipment or occupied zone, graphics for each chilled water and hot water system, and graphics that summarize conditions on each floor of each building included in this contract. Indicate thermal comfort on floor plan summary graphics using colors to represent zone temperature relative to zone set point.
 - 1) Functionality. Graphics shall allow operator to monitor system status, to view a summary of the most important data for each controlled zone or piece of equipment, to use point and-click navigation between zones or equipment, and to edit set points and other specified parameters.
 - 2) Graphic imagery – graphics shall use 3D images for all standard and custom graphics. The only allowable exceptions will be photo images, maps, schematic drawings, and selected floor plans.
 - 3) Animation. Graphics shall be able to animate by displaying different Image lies for changed object status.
 - 4) Alarm Indication. Indicate areas or equipment in an alarm condition using color or other visual indicator.
 - 5) Format. Graphics shall be saved in an industry-standard format such as BMP, JPEG, PNG, or GIF. Web-based system graphics shall be viewable on browsers compatible with World Wide Web Consortium browser standards. Web graphic format shall require no plug-in (such as HTML and JavaScript) or shall only require widely available no-cost plug-ins (such as Active-X and Macromedia Flash).
- j. Custom Graphics
 - 1) The operator interface shall be capable of displaying custom graphics in order to convey the status of the facility to its operators.
 - 2) Graphical Navigation. The operator interface shall provide dynamic color graphics of building areas, systems and equipment.
 - 3) Graphical Data Visualization. The operator interface shall support dynamic points including analog and binary values, dynamic text, static text, and animation files.
 - 4) Custom background images. Custom background images shall be created with the use of commonly available graphics packages such as Adobe Photoshop. The graphics generation package shall create and modify graphics that are saved in industry standard formats such as GIF and JPEG.
- k. Graphics Library. Furnish a library of standard HVAC equipment such as chillers, air handlers, terminals, fan coils, unit ventilators, rooftop units, and VAV boxes, in 3-dimensional graphic depictions. The library shall be furnished in a file format compatible with the graphics generation package program.
- l. Manual Control and Override.

- 1) Point Control. Provide a method for a user to view, override, and edit if applicable, the status of any object and property in the system. The point status shall be available by menu, on graphics or through custom programs.
 - 2) Temporary Overrides. The user shall be able to perform a temporary override wherever an override is allowed, automatically removing the override after a specified period of time.
 - 3) Override Owners. The system shall convey to the user the owner of each override for all priorities that an override exists.
 - 4) Provide a specific icon to show timed override or operator override, when a point, unit controller or application has been overridden manually.
- m. Engineering Units
- 1) Allow for selection of the desired engineering units (i.e. Inch pound or SI) in the system.
 - 2) Unit selection shall be able to be customized by locality to select the desired units for each measurement.
 - 3) Engineering units on this project shall be IP.
- B. Scheduling. A user shall be able to perform the following tasks utilizing the operator interface:
- a. Create a new schedule, defining the default values, events and membership.
 - b. Create exceptions to a schedule for any given day.
 - c. Apply an exception that spans a single day or multiple days.
 - d. View a schedule by day, week and month.
 - e. Exception schedules and holidays shall be shown clearly on the calendar.
 - f. Modify the schedule events, members and exceptions.
- C. Trend Logs
- a. Trend Logs Definition.
 - 1) The operator interface shall allow a user with the appropriate security permissions to define a trend log for any data in the system.
 - 2) The operator interface shall allow a user to define any trend log options as described in the Application and Control Software section.
 - b. Trend Log Viewer.
 - 1) The operator interface shall allow Trend Log data to be viewed and printed.
 - 2) The operator interface shall allow a user to view trend log data in text-based (time – stamp/value).
 - 3) The operator shall be able to view the data collected by a trend log in a graphical chart in the operator interface.
 - 4) Trend log viewing capabilities shall include the ability to show a minimum of 5 points on a chart.
 - 5) Each data point trend line shall be displayed as a unique color.
 - 6) The operator shall be able to specify the duration of historical data to view by scrolling and zooming.
 - 7) The system shall provide a graphical trace display of the associated time stamp and value for any selected point along the x-axis.
 - c. Export Trend Logs.
 - 1) The operator interface shall allow a user to export trend log data in CSV or PDF format for use by other industry standard word processing and spreadsheet packages.
- D. Alarm/Event Notification
- a. An operator shall be notified of new alarms/events as they occur while navigating through any part of the system via an alarm icon.

- b. Alarm/Event Log. The operator shall be able to view all logged system alarms/events from any operator interface.
 - 1) The operator shall be able to sort and filter alarms from events. Alarms shall be sorted in a minimum of 4 categories based on severity.
 - 2) Alarm/event messages shall use full language, easily recognized descriptors.
 - 3) An operator with the proper security level may acknowledge and clear alarms/events.
 - 4) All alarms/events that have not been cleared by the operator shall be stored by the building controller.
 - 5) The alarm/event log shall include a comment field for each alarm/event that allows a user to add specific comments associated with any alarm.
- c. Alarm Processing.
 - 1) The operator shall be able to configure any object in the system to generate an alarm when transitioning in and out of a normal state.
 - 2) The operator shall be able to configure the alarm limits, warning limits, states, and reactions for each object in the system.
- E. Reports and Logs.
 - a. The operator interface shall provide a reporting package that allows the operator to select reports.
 - b. The operator interface shall provide the ability to schedule reports to run at specified intervals of time.
 - c. The operator interface shall allow a user to export reports and logs from the building controller in a format that is readily accessible by other standard software applications including spreadsheets and word processing. Acceptable formats include:
 - 1) CSV, HTML, XML, PDF
 - d. Reports and logs shall be readily printed to the system printer.
 - e. Provide a means to list and access the last 10 reports viewed by the user.
 - f. The following standard reports shall be available without requiring a user to manually configure the report:
 - 1) All Points in Alarm Report: Provide an on demand report showing all current alarms.
 - 2) All Points in Override Report: Provide an on demand report showing all overrides in effect.
 - 3) Points report: Provide a report that lists the current value of all points

2.4 DDC EQUIPMENT

- A. Application Software:
 - a. I/O capability from operator station.
 - b. System security for each operator via software password and access levels.
 - c. Automatic system diagnostics; monitor system and report failures.
 - d. Database creation and support.
 - e. Automatic and manual database save and restore.
 - f. Dynamic color graphic displays with up to 10 screen displays at once.
 - g. Custom graphics generation and graphics library of HVAC equipment and symbols.
 - h. Alarm processing, messages, and reactions.
 - i. Trend logs retrievable in spreadsheets and database programs.
 - j. Alarm and event processing.
 - k. Object and property status and control.

- l. Automatic restart of field equipment on restoration of power.
 - m. Data collection, reports, and logs. Include standard reports for the following:
 - 1) Current values of all objects.
 - 2) Current alarm summary.
 - 3) Disabled objects.
 - 4) Alarm lockout objects.
 - 5) Logs.
 - n. Custom report development.
 - o. Workstation application editors for controllers and schedules.
 - p. Maintenance management.
- B. I/O Interface: Hardwired inputs and outputs may tie into system through controllers. Protect points so that shorting will cause no damage to controllers.
- 1. Binary Inputs: Allow monitoring of on-off signals without external power.
 - 2. Pulse Accumulation Inputs: Accept up to 10 pulses per second.
 - 3. Analog Inputs: Allow monitoring of low-voltage (0- to 10-V dc), current (4 to 20 mA), or resistance signals.
 - 4. Binary Outputs: Provide on-off or pulsed low-voltage signal, selectable for normally open or normally closed operation with three-position (on-off-auto) override switches and status lights.
 - 5. Analog Outputs: Provide modulating signal, either low voltage (0- to 10-V dc) or current (4 to 20 mA) with status lights, two-position (auto-manual) switch, and manually adjustable potentiometer.
 - 6. Tri-State Outputs: Provide two coordinated binary outputs for control of three-point, floating-type electronic actuators.
 - 7. Universal I/Os: Provide software selectable binary or analog outputs.
- C. Power Supplies: Transformers with Class 2 current-limiting type or overcurrent protection; limit connected loads to 80 percent of rated capacity. DC power supply shall match output current and voltage requirements and be full-wave rectifier type with the following:
- 1. Output ripple of 5.0 mV maximum peak to peak.
 - 2. Combined 1 percent line and load regulation with 100-mic.sec. response time for 50 percent load changes.
 - 3. Built-in overvoltage and overcurrent protection and be able to withstand 150 percent overload for at least 3 seconds without failure.
- D. Interface Software: Provide all software with full access licenses on CD-ROM's to access, interface and modify the DDC system. Provide all patch cables required to interface with DDC controllers.

2.5 DDC CONTROLLERS

- A. No controller shall be loaded to more than 80%. IE: A controller with 20 available points shall be loaded with 16 points or less.
- B. DDC controllers shall be stand-alone, multi-tasking, multi-user, real-time digital control processors consisting of modular hardware with plug-in enclosed processors, communication

controllers, power supplies and input/output point modules. Controller size shall be sufficient to fully meet the requirements of the contract documents. Each controller shall support a minimum of two (2) LAN Device Networks.

- C. Each DDC controller shall have sufficient memory to support its own operating system and databases, including:
 - 1. Control processes
 - 2. Energy management applications
 - 3. Alarm management applications including custom alarm messages for each level alarm for each point in the system.
 - 4. Historical/trend data for points specified.
 - 5. Maintenance support applications.
 - 6. Custom processes.
 - 7. Operator I/O.
 - 8. Dial-up communications.
 - 9. Manual override monitoring.
- D. Each DDC controller shall support any combination of industry standard inputs and outputs.
- E. Provide all processors, power supplies and communication controllers so that the implementation of a point only requires the addition of the appropriate point input/output termination module and wiring.
- F. DDC controllers shall provide a minimum two RS-232C serial data communication ports for operation of operator I/O devices such as industry standard printers, operator terminals, modems and portable laptop operator's terminals. DDC controllers shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, Ethernet connections, printers, or terminals.
- G. Each DDC controller shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all panel components. The DDC controller shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication.
- H. Isolation shall be provided at all peer-to-peer network terminations, as well as all field point terminations to suppress induced voltage transients consistent with IEEE Standards 587-1980.
- I. In the event of the loss of normal power, there shall be an orderly shutdown of all DDC controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 100 days.
 - 1. Upon restoration of normal power, the DDC controller shall automatically resume full operation without manual intervention.
 - 2. Should DDC controller memory be lost for any reason, the system shall automatically reload the DDC controller via the local RS-232C port, via telephone line dial-in or Ethernet from the existing network workstation PC.
- J. Provide a separate DDC controller for each RTU or other HVAC system. It is intended that each unique system be provided with its own point resident DDC controller.

2.6 DDC CONTROLLER RESIDENT SOFTWARE FEATURES

- A. General:
 - 1. The software programs specified in this Section shall be provided as an integral part of DDC Controllers and shall not be dependent upon any higher-level computer for execution.
- B. Control Software Description:
 - 1. The DDC Controllers shall have the ability to perform the following pre-tested control algorithms:
 - a. Two-position control
 - b. Proportional control
 - c. Proportional plus integral control
 - d. Proportional, integral, plus derivative control
 - e. Automatic tuning of control loops
- C. DDC Controllers shall have the ability to perform any or all the following energy management routines:
 - 1. Time-of-day scheduling
 - 2. Calendar-based scheduling
 - 3. Holiday scheduling
 - 4. Temporary schedule overrides
 - 5. Start-Stop Time Optimization
 - 6. Automatic Daylight Savings Time Switchover
 - 7. Night setback control
 - 8. Enthalpy switchover (economizer)
 - 9. Peak demand limiting
 - 10. Temperature-compensated duty cycling
- D. DDC Controllers shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.
- E. Alarm management shall be provided to monitor and direct alarm information to operator devices. Each DDC Controller shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic and prevent alarms from being lost. At no time shall the DDC Controllers ability to report alarms be affected by either operator or activity at a PC workstation, local I/O device or communications with other panels on the network.
- F. A variety of historical data collection utilities shall be provided to manually or automatically sample, store and display system data for points as specified.

2.7 APPLICATION SPECIFIC CONTROLLERS (ASC)

- A. Each DDC Controller shall be able to extend its performance and capacity through the use of remote application specific controllers (ASCs) through LAN Device Networks.
- B. Each ASC shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each ASC shall be a

microprocessor-based, multi-tasking, real-time digital control processor. Provide the following types of ASCs as a minimum:

1. Terminal Equipment Controllers
- C. Each ASC shall be capable of control of the terminal device independent of the manufacturer of the terminal device.
- D. Terminal Equipment Controllers:
1. Provide for control of each piece of equipment , including, but not limited to, the following:
 - a. Terminal units
 - b. Exhaust fans

2.8 ELECTRONIC SENSORS

- A. Description: Vibration and corrosion resistant; for wall, immersion, or duct mounting as required.
- B. Thermistor Temperature Sensors and Transmitters and Resistance Temperature Detectors and Transmitters:
1. Accuracy: Plus or minus 0.5 deg F at calibration point.
 2. Wire: Twisted, shielded-pair cable.
 3. Insertion Elements in Ducts: Single point, 8 inches long; use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft.
 4. Averaging Elements in Ducts: 36 inches long, flexible; use where prone to temperature stratification or where ducts are larger than 10 sq. ft.
 5. Insertion Elements for Liquids: Brass or stainless-steel socket with minimum insertion length of 2-1/2 inches.
 6. Room Sensor Cover Construction:
 - a. Set-Point Adjustment : Exposed Warmer/cooler slider (range of adjustable control shall be programmable and adjustable through the BAS, default +-2°F)
 - b. Set-Point Indication: Concealed.
 - c. Thermometer: Concealed.
 - d. Color: Manufacturer's standard.
 - e. Orientation: Vertical.
 7. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.
 8. Corridors & Restrooms: In corridors, entrances, and restrooms provide blank stainless-steel cover plate sensors with insulated back and security screws.
- C. Humidity Sensors: Capacitance or bulk polymer resistance type.
1. Accuracy: 5 percent full range with linear output.
 2. Room Sensor Range: 20 to 80 percent relative humidity.
 3. Room Sensor Cover Construction: Manufacturer's standard locking covers.
 - a. Color: Manufacturer's standard.
 - b. Orientation: Vertical.
 4. Outside-Air Sensor: 20 to 80 percent relative humidity range with mounting enclosure, suitable for operation at outdoor temperatures of 0 to 185 deg F.
 5. Duct-Mounted: Electric insertion, 2-position type with adjustable, 2 percent throttling range, 20 to 80 percent operating range, and single- or double-pole contacts.

- D. Pressure Transmitters/Transducers:
1. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input and temperature-compensated.
 - a. Accuracy: 2 percent of full scale with repeatability of 0.5 percent.
 - b. Output: 4 to 20 mA.
 - c. Building Static-Pressure Range: 0- to 0.25-inch wg.
 - d. Duct Static-Pressure Range: 0- to 5-inch wg.
 2. Water Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure; linear output 4 to 20 mA.
 3. Water Differential-Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure and tested to 300-psig; linear output 4 to 20 mA.
 4. Differential-Pressure Switch (Air or Water): Snap acting, with pilot-duty rating and with suitable scale range and differential. Accuracy shall be +/- 5% of range.
 5. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; linear output 4 to 20 mA.
- E. Current Sensing Switch:
1. Sensor supply voltage and supply current shall be induced from monitored conductor. Contact rating shall be 0.2 amperes at 30 volts DC/AC. Trip set point shall be adjustable to +/-1% of range. Current sensing switch wiring shall not be polarity sensitive.

2.9 STATUS SENSORS

- A. Status Inputs for Fans: Differential-pressure switch with pilot-duty rating and with adjustable range of 0- to 5-inch wg.
- B. Status Inputs for Pumps: Differential-pressure switch with pilot-duty rating and with adjustable pressure-differential range of 8 to 60 psig, piped across pump.
- C. Status Inputs for Electric Motors: Comply with ISA 50.00.01, current-sensing fixed- or split-core transformers with self-powered transmitter, adjustable and suitable for 175 percent of rated motor current.
- D. Voltage Transmitter (100- to 600-V ac): Comply with ISA 50.00.01, single-loop, self-powered transmitter, adjustable, with suitable range and 1 percent full-scale accuracy.
- E. Power Monitor: 3-phase type with disconnect/shorting switch assembly, listed voltage and current transformers, with pulse kilowatt hour output and 4- to 20-mA kW output, with maximum 2 percent error at 1.0 power factor and 2.5 percent error at 0.5 power factor.
- F. Current Switches: Self-powered, solid-state with adjustable trip current, selected to match current and system output requirements.
- G. Electronic Valve/Damper Position Indicator: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.

- H. Water-Flow Switches: Bellows-actuated mercury or snap-acting type with pilot-duty rating, stainless-steel or bronze paddle, with appropriate range and differential adjustment, in NEMA 250, Type 1 enclosure.

2.10 THERMOSTATS

- A. Available Manufacturers:
1. Danfoss Inc.; Air-Conditioning and Refrigeration Div.
 2. Heat-Timer Corporation.
 3. Tekmar Control Systems, Inc.
- B. Combination Thermostat and Fan Switches: Line-voltage thermostat with push-button or lever-operated fan switch.
1. Label switches "FAN ON-OFF" or "FAN HIGH-LOW-OFF" or "FAN HIGH-MED-LOW-OFF."
 2. Mount on single electric switch box.
- C. Electric, solid-state, microcomputer-based room thermostat with remote sensor.
1. Automatic switching from heating to cooling.
 2. Preferential rate control to minimize overshoot and deviation from set point.
 3. Set up for four separate temperatures per day.
 4. Instant override of set point for continuous or timed period from 1 hour to 31 days.
 5. Short-cycle protection.
 6. Programming based on every day of week.
 7. Selection features include degree F or degree C display, 12- or 24-hour clock, keyboard disable, remote sensor, and fan on-auto.
 8. Battery replacement without program loss.
 9. Thermostat display features include the following:
 - a. Time of day.
 - b. Actual room temperature.
 - c. Programmed temperature.
 - d. Programmed time.
 - e. Duration of timed override.
 - f. Day of week.
 - g. System mode indications include "heating," "off," "fan auto," and "fan on."
- D. Low-Voltage, On-Off Thermostats: NEMA DC 3, 24-V, bimetal-operated, mercury-switch type, with adjustable or fixed anticipation heater, concealed set-point adjustment, 55 to 85 deg F set-point range, and 2 deg F maximum differential.
- E. Line-Voltage, On-Off Thermostats: Bimetal-actuated, open contact or bellows-actuated, enclosed, snap-switch or equivalent solid-state type, with heat anticipator; listed for electrical rating; with concealed set-point adjustment, 55 to 85 deg F set-point range, and 2 deg F maximum differential.
1. Electric Heating Thermostats: Equip with off position on dial wired to break ungrounded conductors.
 2. Selector Switch: Integral, manual on-off-auto.

- F. Remote-Bulb Thermostats: On-off or modulating type, liquid filled to compensate for changes in ambient temperature; with copper capillary and bulb, unless otherwise indicated.
 - 1. Bulbs in water lines with separate wells of same material as bulb.
 - 2. Bulbs in air ducts with flanges and shields.
 - 3. Averaging Elements: Copper tubing with either single- or multiple-unit elements, extended to cover full width of duct or unit; adequately supported.
 - 4. Scale settings and differential settings are clearly visible and adjustable from front of instrument.
 - 5. On-Off Thermostat: With precision snap switches and with electrical ratings required by application.
 - 6. Modulating Thermostats: Construct so complete potentiometer coil and wiper assembly is removable for inspection or replacement without disturbing calibration of instrument.

- G. Immersion Thermostat: Remote-bulb or bimetal rod-and-tube type, proportioning action with adjustable throttling range and adjustable set point.

- H. Airstream Thermostats: Two-pipe, fully proportional, single-temperature type; with adjustable set point in middle of range, adjustable throttling range, plug-in test fitting or permanent pressure gage, remote bulb, bimetal rod and tube, or averaging element.

- I. Electric, Low-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual- or automatic- reset switch that trips if temperature sensed across any 12 inches of bulb length is equal to or below set point.
 - 1. Bulb Length: Minimum 20 feet.
 - 2. Quantity: One thermostat for every 20 sq. ft. of coil surface.

- J. Electric, High-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual- or automatic- reset switch that trips if temperature sensed across any 12 inches of bulb length is equal to or above set point.
 - 1. Bulb Length: Minimum 20 feet.
 - 2. Quantity: One thermostat for every 20 sq. ft. of coil surface.

- K. Heating/Cooling Valve-Top Thermostats: Proportional acting for proportional flow, with molded-rubber diaphragm, remote-bulb liquid-filled element, direct and reverse acting at minimum shutoff pressure of 25 psig, and cast housing with position indicator and adjusting knob.

2.11 ACTUATORS

- A. Electric Motors: Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
 - 1. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
 - 2. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in

- housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
3. Nonspring-Return Motors for Valves Larger than NPS 2-1/2: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.
 4. Spring-Return Motors for Valves Larger than NPS 2-1/2: Size for running and breakaway torque of 150 in. x lbf.
 5. Nonspring-Return Motors for Dampers Larger than 25 Sq. Ft.: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.
 6. Spring-Return Motors for Dampers Larger than 25 Sq. Ft.: Size for running and breakaway torque of 150 in. x lbf.
- B. Electronic Actuators: Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
1. Valves: Size for torque required for valve close off at maximum pump differential pressure.
 2. Dampers: Size for running torque calculated as follows:
 - a. Parallel-Blade Damper with Edge Seals: 7 inch-lb/sq. ft. of damper.
 - b. Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. of damper.
 - c. Parallel-Blade Damper without Edge Seals: 4 inch-lb/sq. ft. of damper.
 - d. Opposed-Blade Damper without Edge Seals: 3 inch-lb/sq. ft. of damper.
 - e. Dampers with 2- to 3-Inch wg of Pressure Drop or Face Velocities of 1000 to 2500 fpm: Increase running torque by 1.5.
 - f. Dampers with 3- to 4-Inch wg of Pressure Drop or Face Velocities of 2500 to 3000 fpm: Increase running torque by 2.0.
 3. Coupling: V-bolt and V-shaped, toothed cradle.
 4. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
 5. Fail-Safe Operation: Mechanical, spring-return mechanism. Provide external, manual gear release on nonspring-return actuators.
 6. Power Requirements (Modulating): Maximum 10 VA at 24-V ac or 8 W at 24-V dc.
 7. Proportional Signal: 2- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
 8. End switch: Provide end switch to confirm damper open and/or closed per drawings.
 9. Temperature Rating: Minus 22 to plus 122 deg F.

2.12 DAMPERS

- A. Dampers: AMCA-rated, parallel or opposed-blade design; 0.108-inch- minimum thick, galvanized-steel or 0.125-inch- minimum thick, extruded-aluminum frames with holes for duct mounting; damper blades shall not be less than 0.064-inch- thick galvanized steel with maximum blade width of 8 inches and length of 48 inches.
1. Secure blades to 1/2-inch- diameter, zinc-plated axles using zinc-plated hardware, with oil-impregnated sintered bronze blade bearings, blade-linkage hardware of zinc-plated steel and brass, ends sealed against spring-stainless-steel blade bearings, and thrust bearings at each end of every blade.
 2. Operating Temperature Range: From minus 40 to plus 200 deg F.
 3. Edge Seals, Standard Pressure Applications: Closed-cell neoprene.

4. Edge Seals, Low-Leakage Applications: Use inflatable blade edging or replaceable rubber blade seals and spring-loaded stainless-steel side seals, rated for leakage at less than 10 cfm per sq. ft. of damper area, at differential pressure of 4-inch wg when damper is held by torque of 50 in. x lbf; when tested according to AMCA 500D.

2.13 SMOKE DETECTORS

- A. Smoke detectors shall be furnished under Division 28 and installed under this Section.
- B. Wiring from smoke detectors to fire alarm system shall be under Division 28.
- C. Wiring from smoke detectors to mechanical equipment shall be under this Section.

2.14 LOW TEMPERATURE DETECTION STAT: By BAS manufacturer.

2.15 CURRENT SENSING RELAYS: By controls contractor for all equipment.

2.16 MISCELLANEOUS RELAYS AND SWITCHES:

- A. General: Where required by the sequence of operation switches, relays, and miscellaneous devices necessary to accomplish the sequence shall be provided under this Section.

PART 3 - EXECUTION

3.1 PROJECT MANAGEMENT

- A. Provide a designated project manager who will be responsible for the following:
 1. Construct and maintain project schedule
 2. On-site coordination with all applicable trades and subcontractors
 3. Authorized to accept and execute orders or instructions from owner/architect
 4. Attend project meetings as necessary to avoid conflicts and delays
 5. Make necessary field decisions relating to this scope of work
 6. Coordination/Single point of contact.

3.2 EXAMINATION

- A. Verify that power supply is available to control units.
- B. Verify that duct-, pipe-, and equipment-mounted devices are installed before proceeding with installation.

3.3 INSTALLATION

- A. Install software in control units and operator workstation(s). Implement all features of programs to specified requirements and as appropriate to sequence of operation.
- B. Connect and configure equipment and software to achieve sequence of operation specified in Section 23 section "Sequence of Control."
- C. Verify location of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices next to light switch (es) when space is available with top of device at 48 inches above finished floor. Where space next to light switch (es) is not available, align device vertically with light switch and locate device with top at 40 inches above the finished floor.
 - 1. Install averaging elements in ducts and plenums in crossing or zigzag pattern.
- D. Install guards on thermostats where indicated on Drawings.
- E. Install automatic dampers according to Division 23 Section "Air Duct Accessories."
- F. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.
- G. Install labels and nameplates to identify control components according to Division 23 Section "Identification for HVAC Piping and Equipment."
- H. Install duct volume-control dampers according to Division 23 Sections specifying air ducts.

3.4 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. Perform the following field tests and inspections and prepare test reports:
 - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
 - 2. Test and adjust controls and safeties.
 - 3. Test calibration of electronic controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
 - 4. Test each point through its full operating range to verify that safety and operating control set points are as required.
 - 5. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
 - 6. Test each system for compliance with sequence of operation.
 - 7. Test software and hardware interlocks.
- C. DDC Verification:

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1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
 2. Check instruments for proper location and accessibility.
 3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
 4. Check instrument tubing for proper fittings, slope, material, and support.
 5. Check flow instruments. Inspect tag number and line and bore size, and verify that inlet side is identified and that meters are installed correctly.
 6. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.
 7. Check temperature instruments and material and length of sensing elements.
 8. Check control valves. Verify that they are in correct direction.
 9. Check DDC system as follows:
 - a. Verify that DDC controller power supply is from emergency power supply.
 - b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
 - c. Verify that spare I/O capacity has been provided.
 - d. Verify that DDC controllers are protected from power supply surges.
- D. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

3.5 ADJUSTING

A. Calibrating and Adjusting:

1. Calibrate instruments.
2. Make three-point calibration test for both linearity and accuracy for each analog instrument.
3. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.
4. Control System Inputs and Outputs:
 - a. Check analog inputs at 0, 50, and 100 percent of span.
 - b. Check analog outputs using milliampere meter at 0, 50, and 100 percent output.
 - c. Check digital inputs using jumper wire.
 - d. Check digital outputs using ohmmeter to test for contact making or breaking.
 - e. Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.
5. Flow:
 - a. Set differential pressure flow transmitters for 0 and 100 percent values with 3-point calibration accomplished at 50, 90, and 100 percent of span.
 - b. Manually operate flow switches to verify that they make or break contact.
6. Pressure:
 - a. Calibrate pressure transmitters at 0, 50, and 100 percent of span.

- b. Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.
 - 7. Temperature:
 - a. Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source.
 - b. Calibrate temperature switches to make or break contacts.
 - 8. Stroke and adjust control valves and dampers without positioners, following the manufacturer's recommended procedure, so that valve or damper is 100 percent open and closed.
 - 9. Stroke and adjust control valves and dampers with positioners, following manufacturer's recommended procedure, so that valve and damper is 0, 50, and 100 percent closed.
 - 10. Provide diagnostic and test instruments for calibration and adjustment of system.
 - 11. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.
- B. Adjust initial temperature and humidity set points.
- C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to three visits to Project during other than normal occupancy hours for this purpose.

3.6 TRAINING

- A. Provide 8 hours of training for Owner's designated operating personnel. Training shall include:
 - 1. Explanation of drawings and operation & maintenance manuals
 - 2. Walk-through of the job to locate control components
 - 3. Operator workstation and peripherals
 - 4. DDC controller and ASC operation/function
 - 5. Operator control functions including graphic generation and field panel programming
 - 6. Explanation of adjustment, calibration and replacement procedures
- B. Since the Owner may require personnel to have more comprehensive understanding of the hardware and software, additional training must be available from the Manufacturer. If necessary additional training will be contracted by the Owner at a later date.
- C. Coordinate with Owner is videotape documentation of training is required.

END OF SECTION 230900

SECTION 230993 - SEQUENCE OF OPERATIONS FOR HVAC CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Provisions of the Contract and Contract Documents apply to this Section.

1.2 SUMMARY

- A. This Section includes control sequences for HVAC systems, subsystems, and equipment.
- B. Related Sections include the following:
 - 1. Division 23 Section "Building Automation System" for control equipment, devices and submittal requirements.

1.3 DEFINITIONS

- A. BAS: Building automation system.
- B. CO₂: Carbon dioxide.
- C. DDC: Direct digital control.
- D. PPM: Parts per million.
- E. RPM: Revolutions per minute.
- F. VFD: Variable-frequency drive

1.4 GENERAL REQUIREMENTS OF THIS SECTION

- A. Control sequences shall be accomplished in accordance with control drawings and the sequences specified in this section. It is the intent of this section to utilize sequences included in pre-programmed controllers when such sequences provide the intended operation.
- B. Points may not be deleted without prior approval from the Architect.
- C. Every attempt has been made to indicate all required points on the control drawings. Occasionally an additional point, or points, may be required to accomplish a specified sequence. The contractor performing work under this section shall understand the work to be implied and required by the contract documents. Additional hardware and software required shall be provided under section "Building Automation System" at no additional cost to the owner.

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1. Such points include:
 - a. Sensors of all types whether or not specified under section "Building Automation System"
 - b. Flow measuring stations.
 - c. Wiring, conduit, and related devices such as relays.
2. Exceptions:
 - a. Equipment and devices covered under sections other than "Building Automation System."

1.5 DISPLAY GRAPHICS:

- A. Include system schematic for each system. Indicate all points in system on at least one graphic.
- B. Indicate all commanded values and temperatures.
- C. Indicate all sensed temperatures.
- D. Indicate all alarms.
- E. Indicate all status points.
- F. Indicate all monitored conditions.

1.6 WARRANTY

- A. Provide all services, materials and equipment necessary for the successful operation of the entire BAS system for a period of one year beginning on the date of substantial completion.

1.7 SUBMITTALS

- A. Refer to section "Building Automation System."

PART 2 - SEQUENCES

2.1 SET POINTS: Unless indicated otherwise all set points shall be adjustable from the head end.

2.2 OCCUPIED / UNOCCUPIED / UNOCCUPIED MAINTENANCE

- A. The BAS shall institute occupied /unoccupied maintenance/and unoccupied control sequences based on a time-of-day schedule furnished by the Owner.
- B. The Owner shall have the capability to program holidays and special functions.
- C. The Owner shall have the ability to override occupied / unoccupied maintenance / and unoccupied operation of each piece of equipment from the head end.

2.3 UNOCCUPIED MAINTENANCE MODE

- A. During unoccupied maintenance mode, the BAS shall provide temperature control as described for occupied operation and shall provide outdoor air control as described for unoccupied operation.

2.4 OPTIMUM START/STOP:

- A. The BAS shall institute optimum start strategies for morning warm up and cool down functions. Equipment shall start early enough to restore occupied temperature set points 30 minutes prior to occupancy.
- B. The BAS shall institute optimum stop strategies for shutting down units before scheduled unoccupied operation to allow zones to coast to unoccupied operation without affecting occupied set points.

2.5 OUTSIDE AIR SENSORS:

- A. Temperature: The BAS shall monitor outside air temperature as sensed by the outside air temperature sensor.
- B. Humidity: The BAS shall monitor outside air relative humidity as sensed by the outside air humidity sensor.
- C. Dew Point: Utilizing information provided by the outside air temperature and humidity sensor the BAS shall report current outside air dew point.

2.6 GENERAL SYSTEM REQUIREMENTS

- A. System Failure: The control system shall be installed to fail safe to heating mode.
 - 1. All air handling units shall fail with outside air dampers closed and heating valves open to the coil.
 - 2. Night setback shall fail to occupied mode.
 - 3. All interlocked fans shall be de-energized with dampers closed.

2.7 VARIABLE REFRIGERANT FLOW SYSTEM

- A. The BAS shall enable, disable, and schedule (occupied or unoccupied) the systems through a BACnet interface. The VRF systems shall operate under the VRF system controls once enabled. The BAS shall send, at a minimum, the following points to the unit:
 - 1. Operation mode/schedule
 - 2. Zone temperature setpoints
 - 3. Setpoint range limitation
 - 4. Enable/Disable iTM auto-changeover operation

- B. The BAS shall indicate, at a minimum, receive the follow points at the head end from the VRF controller via the BACnet interface:
 - 1. Alarm status with error description
 - 2. Zone temperature
 - 3. Indoor unit operation mode
 - 4. Fan status
 - 5. Compressor status
 - 6. Occupancy mode

- C. Initial Set Points:
 - 1. Occupied:
 - a. Cooling Space Temperature: 75°F.
 - b. Heating Space Temperature: 70°F.
 - 2. Unoccupied:
 - a. Cooling Space Temperature: 85°F.
 - b. Heating Space Temperature: 65°F.

2.8 OUTSIDE AIR UNITS (DOAU-1)

- A. The BAS shall interface to the packaged controls for the outside air unit. The BAS shall enable, disable, and schedule (occupied or unoccupied) the system through a BACnet interface. The unit shall operate under its packaged unit controls once enabled.

- B. The BAS shall indicate, at a minimum, the follow points at the head end via the BACnet interface:
 - 1. Unit status
 - 2. Alarms
 - 3. Evaporator discharge air temperature
 - 4. Leaving unit air temperature

- C. Space temperature and humidity monitoring: The BAS shall provide space temperature and humidity sensors and integrate that into this unit for control with remote temperature and humidity sensors to place unit into dehumidification mode and to optimize leaving air temperature.

- D. Unit should be provided with discharge and return temperature and humidity sensors for BAS monitoring. If these sensors can be provided with factory controls and integrated through BACnet interface this is acceptable in lieu of field installed sensors in ductwork.

- C. Smoke Detection Shut Down
 - 1. When smoke is detected at any one of the four existing duct smoke detectors, the fire alarm system shall open a set of contacts and shut down both fans with a hard-wired interface to the supply fan VFD.
 - 2. When the BAS detects a fan shut down due to the detection of smoke, the BAS shall shutdown all associated terminal units. The BAS shall leave the unit Supply Fan under scheduled control, ready to restart when the fire alarm system is cleared, but shut down the rest of the unit and configure the control outputs for a staggered, coordinated restart when the safety clears.

2.9 PACKAGED VAV AIR HANDLING UNITS SERVING TERMINAL UNITS (RTU-1)

A. General

1. These air handling units include a variable-speed supply fan, variable-speed exhaust fan, enthalpy wheel, gas burner, and direct-expansion cooling coil. They provide temperature control, humidity control, and economizer cooling for terminal units. Outside air and return dampers will be modulated to provide economizer cooling when conditions are suitable.
2. The BAS shall enable, disable, and schedule (occupied or unoccupied) the unit through a BACnet interface and the unit will operate under its own controls once enabled. The BAS shall send, at a minimum, the following points to unit:
 - a. Duct static pressure set point
 - b. Supply air temperature set point
 - c. Outside airflow set point
 - d. Occupancy mode
3. When the RTU is Switched Off/Shut Down via the BAS, it is to be configured as follows: The supply fan shall be off, the OA and exhaust air dampers shall close, the recirculation damper shall open, cooling shall be disabled, and the hot water control valve shall be closed.

B. Initial Set Points:

1. General:
 - a. Duct Static Pressure: 1" WC (adjusted/ set by TAB agent)
2. Occupied:
 - a. Minimum Supply Air Temperature: 55°F.
 - b. Maximum Supply Air Temperature: 65°F (morning warm-up set point).
 - c. Space Maximum Relative Humidity: 55% RH
 - d. Outdoor Airflow: Refer to equipment schedule
3. Unoccupied:
 - a. Minimum Supply Air Temperature: 55°F.
 - b. Maximum Supply Air Temperature: 65°F (morning warm-up set point).
 - c. Space Maximum Relative Humidity: 60% RH
 - d. Outdoor Airflow: 0 CFM

C. Unit Start/Stop

1. The BAS shall provide Start/Stop control of this RTU based on a user-defined occupancy schedule, and to maintain space temperature and humidity conditions.

D. Dehumidification Mode: During occupied or unoccupied operation when the average relative humidity (as sensed by the space humidity sensors) rises above set point, or any one space humidity sensor is greater than 65%, the unit shall be placed in dehumidification mode. The BAS shall reset the leaving air temperature set point to minimum. The unit shall remain in dehumidification mode until the space relative humidity drops to 5% RH below set point at

which time the BAS shall return to normal leaving air temperature reset control. Refer to applicable paragraphs for operation of valves, dampers, and fans.

E. Duct Static Pressure Reset:

1. The BAS shall continuously monitor the damper position of all terminal units. When any damper opens beyond the maximum set point (initially 95%), the BAS shall reset the down-duct static pressure set point upward by 5% (adjustable) of the maximum static pressure set point. This shall occur at 10 minute (adjustable) intervals until no damper is more than 95% open, or the static pressure set point has been reset upward to the system maximum setting, or the VFD is at its maximum setting. When all dampers are opened less than the minimum set point (initially 85%), the BAS shall reset the down-duct static pressure set-point downward by 5% (adjustable) of the maximum system static pressure set point. This shall occur at 10 minute (adjustable) intervals until any damper is more than 85% open, or the VFD is at its minimum setting.

F. Leaving Air Temperature Reset:

1. Terminal boxes should be polled for cooling or heating demand to optimize leaving air temperature set point and reduce unnecessary terminal box reheat.
2. The supply air temperature setpoint will be reset to the optimal setpoint communicated by the BAS. The BAS will reset the supply air temperature setpoint based on the current outside air temperature, but will override this reset function and return the supply air temperature setpoint to the minimum if more than two (adj.) zones begin to overheat. Also, the BAS will override this reset function whenever outdoor dew point is higher than 60.0 deg. F (adj.) or indoor humidity is higher than 60% RH (adj.).

D. Smoke Detection Shut Down

1. When smoke is detected at the unit mounted duct smoke detector, the fire alarm system shall open a set of contacts and shut down both fans with a hard-wired interface to the supply fan VFD.
2. When the BAS detects a fan shut down due to the detection of smoke, the BAS shall shutdown all associated fan-powered terminal units. The BAS shall leave the unit Supply Fan under scheduled control, ready to restart when the fire alarm system is cleared, but shut down the rest of the unit and configure the control outputs for a staggered, coordinated restart when the safety clears.

G. The BAS shall monitor the drain pan float water level detection device in condensate drain pan. If the drain pan is not draining properly and raises to activate the water level detection device, cooling shall be disabled and an alarm issued to the head end.

H. Unit should be provided with discharge and return temperature and humidity sensors for BAS monitoring. If these sensors can be provided with factory controls and integrated through BACnet interface this is acceptable in lieu of field installed sensors in ductwork.

I. Unit Monitoring and Alarming

1. The BAS shall monitor space temperature, supply air temperature, return air temperature, space humidity, fan status, VFD monitoring points.
2. The BAS system shall accumulate run times for the supply fan motor.

3. The system will accept alarm limits for all the temperature sensors and provide an operator notification as they exceed user defined alarm limits.
 - a. The BAS shall signal an alarm anytime the discharge air temperature is 4°F above or below set point.
 - b. The BAS shall report any detected sensor failure.
4. The system will accept alarm limits for the humidity sensors and provide an operator notification as they exceed user defined alarm limits.
 - a. The BAS shall signal an alarm when any humidity sensor is 5% (adj.) above the set point for more than 60 min.
 - b. The BAS shall report any detected sensor failure.
5. The system will accept alarm limits for the OA Intake Airflow Monitoring Station and provide an operator notification the recorded CFMs exceed user defined alarm limits
 - a. The BAS shall signal an alarm when the OA Intake CFM is 100 CFM above or below the set point for more than 10 min.
 - b. The BAS shall report any detected sensor failure.
6. The BAS shall monitor the low temperature safety and generate an alarm whenever the safety has tripped.
7. The BAS shall monitor the Condensate Alarm Sensor and generate a "Condensate Overflow Alarm" anytime the BAS records an alarm status from the sensor.
8. The BAS shall monitor the two static pressure safeties and generate an appropriate alarm whenever one of these safeties has tripped.
9. The system will accept alarm limits for the supply duct static pressure and provide an operator notification the pressure exceeds user defined alarm limits.
 - a. The BAS shall signal an alarm when the supply duct static pressure is 0.2" w.c. above or below the set point for more than 10 min.
 - b. The BAS shall report any detected sensor failure.

2.10 SERIES FAN POWERED TERMINAL UNIT WITH STEP CONTROLLED ELECTRIC HEAT

- A. DESCRIPTION: Cooling & heating, ceiling mounted, series (constant) fan powered, primary air control, variable air volume terminal unit. The unit contains a characterized damper, a pitot type flow measuring device with transducer, a fan in parallel with primary air, and a step controlled electric heating coil. The velocity of air, as sensed by the flow sensor/transducer combination using a calculation with a known diameter provides flow (CFM) information to the BAS. The temperature of the space, as sensed by the space temperature sensor, allows the controller to determine the required CFM for cooling, when to start the fan, when to start and where to set the number of steps of electric heat.
- B. Set points
 1. Occupied Mode:

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- a. Cooling: 75° F
 - b. Heating: 70° F
 - 2. Unoccupied:
 - a. Cooling: 85° F
 - b. Heating: 60° F
 - C. Fan: Shall run continuously during occupied mode and cycle during unoccupied mode to maintain set point.
 - D. Cooling:
 - 1. On a rise in space temperature, as sensed by the space temperature sensor, above the cooling set point, the BAS shall modulate the terminal unit air valve open in response to the increase in space temperature until the maximum indicated CFM is reached.
 - 2. On a fall in space temperature, as sensed by the space temperature sensor, the reverse shall occur until the minimum indicated CFM is reached.
 - E. Heating:
 - 1. On a fall in space temperature, as sensed by the space temperature sensor, the BAS shall stage on each step of electric heat to maintain space temperature.
 - 2. On a rise in space temperature, as sensed by the space temperature sensor, the reverse shall occur.
 - F. Monitoring points: The following information shall be sent to the BAS by the unitary controller and subsequently displayed on the head end graphics.
 - 1. Electric heat status.
 - 2. Electric heat alarm.
 - 3. Air valve position feedback.
 - 4. Measured/calculated primary air flow.
 - 5. Fan status
 - G. Deadband: A five-degree (5°F) minimum deadband shall be maintained between heating and cooling set points at all times. This shall not be an adjustable value on the head end graphics.
- 2.11 PARALLEL FAN POWERED TERMINAL UNIT WITH STEP CONTROLLED ELECTRIC HEAT
- A. DESCRIPTION: Cooling & heating, ceiling mounted, parallel (intermittently) fan powered, primary air control, variable air volume terminal unit. The unit contains a characterized damper, a pitot type flow measuring device with transducer, a fan in parallel with primary air, and a step controlled electric heating coil. The velocity of air, as sensed by the flow sensor/transducer combination using a calculation with a known diameter provides flow (CFM) information to the BAS. The temperature of the space, as sensed by the space temperature sensor, allows the controller to determine the required CFM for cooling, when to start the fan, when to start and where to set the number of steps of electric heat.

B. Set points

1. Occupied Mode:
 - a. Cooling: 75° F
 - b. Heating: 70° F
2. Unoccupied:
 - a. Cooling: 85° F
 - b. Heating: 60° F

C. Cooling:

1. On a rise in space temperature, as sensed by the space temperature sensor, above the cooling set point, the BAS shall modulate the terminal unit air valve open in response to the increase in space temperature until the maximum indicated CFM is reached.
2. On a fall in space temperature, as sensed by the space temperature sensor, the reverse shall occur until the minimum indicated CFM is reached.

D. Heating:

1. On fall in space temperature, as sensed by the space temperature sensor, to the heating set point the BAS shall start the terminal unit fan.
2. On a continued fall in space temperature, as sensed by the space temperature sensor, the BAS shall stage on each step of electric heat to maintain space temperature.
3. On a rise in space temperature, as sensed by the space temperature sensor, the reverse shall occur.

E. Monitoring points: The following information shall be sent to the BAS by the unitary controller and subsequently displayed on the head end graphics.

1. Electric heat status.
2. Electric heat alarm.
3. Air valve position feedback.
4. Measured/calculated primary air flow.
5. Fan status

F. Deadband: A five-degree (5°F) minimum deadband shall be maintained between heating and cooling set points at all times. This shall not be an adjustable value on the head end graphics.

2.12 TERMINAL UNIT WITH STEP CONTROLLED ELECTRIC HEAT

- A. DESCRIPTION: Cooling & heating with step control of electric heating coil, ceiling mounted, primary air control, variable air volume terminal unit. The unit contains a characterized damper, a pitot type velocity measuring device with transducer, and an electric heating coil. The velocity of air, as sensed by the velocity sensor/transducer combination using a calculation with a known diameter provides flow (CFM) information to the BAS. The temperature of the space, as sensed by the space temperature sensor, allows the controller to determine the required

CFM for cooling, when to start the electric heating coil, and what capacity to require from the electric heating coil.

B. Set points

1. Occupied Mode:

- a. Cooling: 75° F
- b. Heating: 70° F

2. Unoccupied:

- a. Cooling: 85° F
- b. Heating: 60° F

C. Cooling:

- 1. On a rise in space temperature, as sensed by the space temperature sensor, above the cooling set point, the BAS shall modulate the terminal unit air valve open in response to the increase in space temperature until the maximum cooling indicated CFM is reached.
- 2. On a fall in space temperature, as sensed by the space temperature sensor, the reverse shall occur until the minimum cooling indicated CFM is reached.

D. Heating:

- 1. On a fall in space temperature, as sensed by the space temperature sensor, the BAS shall adjust the air valve to maintain the scheduled heating indicated CFM and stage on each step of electric heat to maintain space temperature.
- 2. On a rise in space temperature, as sensed by the space temperature sensor, the reverse shall occur.

E. Monitoring points: The following information shall be sent to the BAS by the unitary controller and subsequently displayed on the head end graphics.

- 1. Electric heat status.
- 2. Electric heat alarm.
- 3. Air valve position feedback.
- 4. Measured/calculated primary air flow.

F. Deadband: A five-degree (5°F) minimum deadband shall be maintained between heating and cooling set points at all times. This shall not be an adjustable value on the head end graphics.

2.13 EXHAUST FANS – CONTROL METHOD BAS SCHEDULE

A. General: These are general duty fans that operate on a time-of-day schedule. Refer to the Fan Schedule for fan information.

B. Occupied/Unoccupied:

- 1. Unoccupied Operation: During unoccupied hours, the fan shall be off and the damper shall be closed.

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2. Occupied Operation: During occupied hours, the fan shall be on and the damper shall be open.
 - C. Start:
 1. At the start of occupied operation, the BAS shall open the motorized damper associated with the fan. Once the damper is confirmed open, the BAS shall start the fan. If the damper is interlocked with fan operation, then the BAS shall start the fan.
 - D. Stop:
 1. At the beginning of unoccupied operation, the BAS shall stop the fan and close the associated damper (or just stop the fan if the damper is interlocked).
 - E. Fan failure alarm:
 1. If the fan fails to start (as sensed by its current sensing relay), an alarm shall be sent to the head end identifying the fan and stating that it has failed to start.
- 2.14 DOMESTIC HOT WATER PUMP (Applies to new recirculation pump and relocated pumps)
- A. During occupied hours, the BAS shall command the pump on.
 - B. During unoccupied hours, the BAS shall command the pump off.
 - C. Should the pump fail to run (as sensed by the current sensing relay) an alarm shall be sent to the head end identifying the pump and stating that it has failed.

END OF SECTION 230993

SECTION 232113 - HYDRONIC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Provisions of the Contract and of the Contract Documents apply to this Section.

1.2 SUBMITTALS

- A. Pre-submittal meeting: The contractor performing work under this section of the specifications shall attend a meeting for the purpose of coordinating with the control system. The meeting shall be held on the project site in the contractor's trailer or other location acceptable to the contractor. The contractor shall be responsible for arranging the meeting. Submittals shall be essentially complete at the time of the meeting so detailed coordination items can be discussed.
- B. Product Data: For each type of the following:
 - 1. Pressure-seal fittings.
 - 2. Valves-Include flow and pressure drop curves/information based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow control valves.
 - 3. Air control devices.
 - 4. Chemical treatment.
 - 5. Hydronic specialties.
- C. Maintenance Data: For hydronic specialties, balancing valves, automatic flow control valves, and special-duty valves to include in maintenance manuals.

1.3 QUALITY ASSURANCE

- A. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.

1.4 COORDINATION

- A. Coordinate layout and installation of hydronic piping and suspension system components with other construction, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.
- B. Coordinate pipe sleeve installations for foundation wall penetrations.
- C. Coordinate piping installation with roof curbs, equipment supports, and roof penetrations. Roof specialties are specified in Division 7 Sections.

- D. Coordinate pipe fitting pressure classes with products specified in related Sections.
- E. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into base. Concrete, reinforcement, and formwork requirements are specified in Division 3 Sections.
- F. Coordinate installation of pipe sleeves for penetrations through exterior walls and floor assemblies. Coordinate with requirements for firestopping specified in Division 7 Section "Penetration Firestopping Systems" for fire and smoke wall and floor assemblies.

1.5 BUILDING AUTOMATION SYSTEM COORDINATION:

- A. If indicated, all wells, valves, taps, dampers, flow stations, etc. furnished under Section "Building Automation System" shall be installed under this Section.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Hydronic piping, components, and installation shall withstand the following minimum working pressure and temperature unless otherwise indicated: 150 psig at 200 degrees F.

2.2 PIPING MATERIALS

- A. General: Refer to Part 3 "Piping Applications" Article for applications of pipe and fitting materials.

2.3 COPPER TUBE AND FITTINGS

- A. Drawn-Temper Copper Tubing: ASTM B 88, Type L.
- B. Annealed-Temper Copper Tubing: ASTM B 88, Type K. (underground installations)
- C. DWV Copper Tubing: ASTM B 306, Type DWV.
- D. Wrought-Copper Fittings: ASME B16.22.
- E. Copper or Bronze Pressure-Seal Fittings:
 - 1. Manufacturers:
 - a. Elkhart Products Corporation.
 - b. Mueller Industries, Inc.
 - c. NIBCO, Inc.
 - d. Viega, LLC.
 - 2. Housing: Copper
 - 3. O-Rings and Pipe Stops: EPDM.

4. Tools: Manufacturer's special tools.
5. Minimum 200 psig working pressure rating at 250°F.

F. Wrought-Copper Unions: ASME B16.22.

2.4 STEEL PIPE AND FITTINGS

- A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; welded and seamless, Grade B, and wall thickness as indicated in "Piping Applications" Article.
- B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in "Piping Applications" Article.
- C. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in "Piping Applications" Article.
- D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in "Piping Applications" Article.
- E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in "Piping Applications" Article.
- F. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.
- G. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
 1. Material Group: 1.1.
 2. End Connections: Butt welding.
 3. Facings: Raised face.
- H. Flexible Connectors: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket; 150-psig minimum working pressure and 250 deg F maximum operating temperature. Connectors shall have flanged or threaded-end connections to match equipment connected and shall be capable of 3/4-inch misalignment.
- I. Spherical, Rubber, Flexible Connectors: Fiber-reinforced rubber body with steel flanges drilled to align with Classes 150 and 300 steel flanges; operating temperatures up to 250 deg F and pressures up to 150 psig.
- J. Steel Pipe Nipples: ASTM A 733, made of same materials and wall thicknesses as pipe in which they are installed.

2.5 PLASTIC PIPE AND FITTINGS

- A. CPVC Plastic Pipe: ASTM F 441/F 441M, with wall thickness as indicated in "Piping Applications" Article.

1. CPVC Plastic Pipe Fittings: Socket-type pipe fittings, ASTM F 438 for Schedule 40 pipe; ASTM F 439 for Schedule 80 pipe.
- B. PVC Plastic Pipe: ASTM D 1785, with wall thickness as indicated in "Piping Applications" Article.
1. PVC Plastic Pipe Fittings: Socket-type pipe fittings, ASTM D 2466 for Schedule 40 pipe; ASTM D 2467 for Schedule 80 pipe.

2.6 JOINING MATERIALS

- A. 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 maximum thickness unless otherwise 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.
- B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
- C. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.
- D. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
- E. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.
- F. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- G. Solvent Cements for CPVC Piping: ASTM F 493.
- H. Solvent Cements for PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.

2.7 TRANSITION FITTINGS

- A. Plastic-to-Metal Transition Fittings:
1. One-piece fitting with one threaded brass or copper insert and one solvent-cement-joint end of material and wall thickness to match plastic pipe material.
- B. Plastic-to-Metal Transition Unions:
1. Brass or copper end, solvent-cement-joint end of material and wall thickness to match plastic pipe material, rubber gasket, and threaded union.

2.8 ROOF PIPING PENETRATIONS

- A. Available Manufacturers:
 - 1. The Pate Company (Model PHA-2)
 - 2. Roof Penetration Housings, LLC (Vault Models with Exit Seals)
 - 3. Roof Products, Inc. (Model RPPC-90).
- B. Provide pipe hood assembly for pipe penetrations through a roof that are not installed within a roof curb. Provide pipe hood assembly for single or multiple pipes to match application.
- C. Pipe hood assembly shall consist of heavy-gauge aluminum construction and removable water-tight top cover, faceplate and 3-sided body for access to interior. Provide separate, fully-welded and insulated aluminum mounting base to isolate hood from galvanized roof curb. Field insulate hood interior and caulk all exposed joints after installation of piping.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

- A. Condensate-Drain Piping: Type DWV, drawn-temper copper tubing, wrought-copper fittings, and soldered joints or Schedule 40 PVC or CPVC plastic pipe and fittings with solvent-welded joints.
 - 1. Exceptions where PVC, CPVC, and other forms of plastic are not permitted:
 - a. Jails.
 - b. Prisons.
 - c. Plenums.
 - d. Locations prohibited by codes or standards.
- B. Air-Vent Piping:
 - 1. Inlet: Same as service where installed.
 - 2. Outlet: Type K, annealed-temper copper tubing with soldered or flared joints.
- C. Safety-Valve-Inlet and -Outlet Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed.
- D. Miscellaneous: Same materials and joining methods as connecting service.

3.2 PIPING INSTALLATIONS

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved in writing on Coordination Drawings.
- B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

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- C. 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.
- D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- E. Install piping to permit valve servicing.
- F. Install piping at indicated slopes.
- 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 groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
- L. Install branch connections to mains using tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.
- M. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.
- N. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.
- O. Install all wells, valves, taps, flow stations, etc. furnished under Section "Building Automation System."
- P. Install exterior piping at a uniform grade of 0.2 percent upward in direction of flow. Interior piping may be installed level.
- Q. Install condensate drain piping at a minimum uniform slope of 1" in 10'-0" in the direction of flow.
- R. Reduce pipe sizes using concentric reducers, or eccentric reducers installed with level side up.
- S. Provide seal around piping penetrations of full height interior walls, both rated and non-rated, that occur above ceilings. Refer to Section 079200 Joint Sealants.
- T. Where piping penetrates a non-fire-resistance-rated floor or floor/ceiling assembly or ceiling membrane of a non-fire-resistance-rated roof/ceiling assembly, provide the following:

1. For noncombustible piping that connects not more than five stories, protect the annular space around the piping with an approved, noncombustible material to resist the free passage of flame and the products of combustion or with a tested and classified through-penetration firestop system.
2. For piping that connects not more than two stories, protect the annular space around the piping with an approved, noncombustible material to resist the free passage of flame and the products of combustion.
3. For piping that penetrates a non-rated wall, protect the annular space around the penetrating piping with an approved, non-combustible materials that resists the free passage of flame and the products of combustion.

3.3 PIPE JOINT CONSTRUCTION

- A. Join pipe and fittings according to the following requirements and Division 23 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 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.
 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are damaged.
 3. Damaged Welds: 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.

3.4 HANGERS AND SUPPORTS

- A. Hanger, support, and anchor devices are specified in Division 23 Section "Hangers and Supports." Comply with requirements below for maximum spacing of supports.
- B. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:
 1. ¾": Maximum span, 7'-0"; minimum rod size, ¼".
 2. 1": Maximum span, 7'-0"; minimum rod size, ¼".
 3. 1½": Maximum span, 9'-0"; minimum rod size, 3/8".

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4. 2": Maximum span, 10'-0"; minimum rod size, 3/8".
 5. 2½": Maximum span, 11'-0"; minimum rod size, 3/8".
 6. 3": Maximum span, 12'-0"; minimum rod size, 3/8".
 7. 4": Maximum span, 14'-0"; minimum rod size, ½".
 8. 6": Maximum span, 17'-0"; minimum rod size, ½".
 9. 8": Maximum span, 19'-0"; minimum rod size, 5/8".
 10. 10": Maximum span, 20'-0"; minimum rod size, ¾".
 11. 12": Maximum span, 23'-0"; minimum rod size, 7/8".
 12. 14": Maximum span, 25'-0"; minimum rod size, 1".
 13. 16": Maximum span, 27'-0"; minimum rod size, 1".
 14. 18": Maximum span, 28'-0"; minimum rod size, 1¼".
 15. 20": Maximum span, 30'-0"; minimum rod size, 1¼".
- C. Where hangers for steel piping are to be suspended from open-web steel joists, install hangers at maximum spacing that will result in hanger loads that comply with the requirements on the structural drawings.
- D. Install hangers for copper piping with the following maximum spacing and minimum rod sizes:
1. ¾": Maximum span, 5'-0"; minimum rod size, ¼".
 2. 1": Maximum span, 6'-0"; minimum rod size, ¼".
 3. 1½": Maximum span, 8'-0"; minimum rod size, 3/8".
 4. 2": Maximum span, 8'-0"; minimum rod size, 3/8".
 5. 2½": Maximum span, 9'-0"; minimum rod size, 3/8".
 6. 3": Maximum span, 10'-0"; minimum rod size, 3/8".
- E. Plastic Piping Hanger Spacing: Space hangers according to pipe manufacturer's written instructions for service conditions. Avoid point loading. Space and install hangers with the fewest practical rigid anchor points.
- F. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.
- 3.5 Where changes in direction or tees occur, place hangers 1/3 of the maximum allowed spacing distance from the change in direction or tee (i.e. if the maximum span is 12 feet, the hanger shall be 4feet from the change in direction or tee). Pipe shall be supported from both sides of a change in direction.
- 3.6 FIELD QUALITY CONTROL
- A. Prepare hydronic piping according to ASME B31.9 and as follows:
1. Leave joints, including welds, uninsulated and exposed for examination during testing.
 2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
 3. Flush system with clean water. Clean strainers.
 4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve.
 5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

- B. Perform the following tests on hydronic piping:
1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
 2. While filling system, use vents installed at high points of system to release trapped air. Use drains installed at low points for complete draining of liquid.
 3. Check expansion tanks to determine that they are not air bound and that system is full of water.
 4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the design pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test.
 5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components and repeat hydrostatic test until there are no leaks.
 6. Prepare written report of testing.

3.7 ADJUSTING

- A. Mark calibrated nameplates of pump discharge valves after hydronic system balancing has been completed, to permanently indicate final balanced position.
- B. Perform these adjustments before operating the system:
1. Open valves to fully open position. Close coil bypass valves.
 2. Check pump for proper direction of rotation.
 3. Set automatic fill valves for required system pressure.
 4. Check air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
 5. Set temperature controls so all coils and equipment are calling for full flow.
 6. Check and set equipment operating temperatures to design requirements.
 7. Lubricate motors and bearings.

3.8 CLEANING

- A. Remove and clean or replace strainer screens. After cleaning and flushing hydronic piping systems, but before balancing, remove disposable fine-mesh strainers.

END OF SECTION 232113

SECTION 232300 - REFRIGERANT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Provisions of the Contract and of the Contract Documents apply to this Section.

1.2 SUBMITTALS

- A. Product Data: For each type of pipe materials and accessory.
- B. Shop Drawings: Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes, flow capacities, slopes of horizontal runs, valve arrangements and locations, wall and floor penetrations, and equipment connection details.
 - 1. Refrigerant piping indicated on Drawings is schematic only. Size piping and design actual piping layout, including pipe and tube sizes to accommodate, as a minimum, proposed equipment, and length of piping to ensure proper operation and compliance with warranties of connected equipment.

1.3 PRODUCT STORAGE AND HANDLING

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

1.4 QUALITY ASSURANCE

- A. ASHRAE Standard: Comply with ASHRAE 15, "Safety Code for Mechanical Refrigeration."
- B. ASME Standard: Comply with ASME B31.5, "Refrigeration Piping."

1.5 COORDINATION

- A. Coordinate layout and installation of refrigerant piping and suspension system components with other construction, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.
- B. Coordinate pipe sleeve installations for wall penetrations.
- C. Coordinate installation of roof curbs, equipment supports, and roof penetrations.
- D. Coordinate pipe sleeve installations for penetrations in exterior walls and floor assemblies. Coordinate with requirements for firestopping.

- E. Coordinate pipe fitting pressure classes with products specified in related Sections.

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

- A. Copper Tube: ASTM B 280, Type ACR, drawn temper, seamless copper tube.
- B. Wrought-Copper Fittings: ASME B16.22.
- C. Wrought-Copper Unions: ASME B16.22.
- D. Brazing Filler Metals: AWS A5.8, BCuP series, copper-phosphorus alloys for general duty brazing, B-CU93P-710/795: ISO 3677, unless otherwise required by equipment manufacturer. Do not use flux when brazing copper-to-copper refrigerant piping.

2.2 VALVES AND SPECIALTIES

- A. 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.

2.3 ROOF PIPING PENETRATIONS

- A. Available Manufacturers:
 - 1. The Pate Company (Model PHA-2)
 - 2. Roof Penetration Housings, LLC (Vault Models with Exit Seals)
 - 3. Roof Products, Inc. (Model RPPC-90).
- B. Provide pipe hood assembly for pipe penetrations through a roof that are not installed within a roof curb. Provide pipe hood assembly for single or multiple pipes to match application.
- C. Pipe hood assembly shall consist of heavy-gauge aluminum construction and removable water-tight top cover, faceplate and 3-sided body for access to interior. Provide separate, fully-welded and insulated aluminum mounting base to isolate hood from galvanized roof curb. Field insulate hood interior and caulk all exposed joints after installation of piping.

2.4 REFRIGERANTS

- A. Available Manufacturers:
 - 1. Atofina Chemicals, Inc.
 - 2. DuPont Company; Fluorochemicals Div.

3. Honeywell, Inc.; Genetron Refrigerants.
 4. INEOS Fluor Americas LLC.
- B. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS FOR REFRIGERANT

- A. For variable refrigerant flow systems, provide Copper, Type ACR, tubing and wrought-copper fittings with brazed joints as required by equipment manufacturer. Installation shall follow manufacturer's written directions.
- B. For non-variable refrigerant flow systems, provide:
1. Suction Lines 1 1/2" and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.
 2. Suction Lines 2" to 4" for Conventional Air-Conditioning Applications: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.
 3. Hot-Gas, and Liquid Lines: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.
 4. Suction Lines for Heat-Pump Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.

3.2 VALVE AND SPECIALTY APPLICATIONS

- A. Unless indicated otherwise, install valves on inlet of indoor evaporators.

3.3 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved in writing 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 enough space for ceiling panel removal.
- F. Install piping adjacent to equipment to allow service and maintenance.

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- 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. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.
- K. 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.
- L. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.
- M. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.
- N. Identify refrigerant piping and valves according to Section "Identification for HVAC Piping and Equipment."
- O. Provide seal around piping penetrations of full height interior walls, both rated and non-rated, that occur above ceilings. Refer to Section 079200 Joint Sealants.
- P. Where piping penetrates a non-fire-resistance-rated floor or floor/ceiling assembly or ceiling membrane of a non-fire-resistance-rated roof/ceiling assembly, provide the following:
 - 1. For noncombustible piping that connects not more than five stories, protect the annular space around the piping with an approved, noncombustible material to resist the free passage of flame and the products of combustion or with a tested and classified through-penetration firestop system.
 - 2. For piping that connects not more than two stories, protect the annular space around the piping with an approved, noncombustible material to resist the free passage of flame and the products of combustion.
 - 3. For piping that penetrates a non-rated wall, protect the annular space around the penetrating piping with an approved, non-combustible materials that resists the free passage of flame and the products of combustion.

3.4 PIPE JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide), during brazing.

- D. Soldered Joints: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook."
- E. 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.

3.5 HANGERS AND SUPPORTS

- A. Hanger, support, and anchor products are specified in 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'-0" long.
 - 2. Roller hangers and spring hangers for individual horizontal runs 20'-0" or longer.
 - 3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20'-0" 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. ½": Maximum span, 60"; minimum rod size, ¼".
 - 2. 5/8": Maximum span, 60"; minimum rod size, ¼".
 - 3. 1": Maximum span, 72"; minimum rod size, ¼".
 - 4. 1 ¼": Maximum span, 96"; minimum rod size, 3/8".
 - 5. 1 ½": Maximum span, 96"; minimum rod size, 3/8".
 - 6. 2": Maximum span, 96"; minimum rod size, 3/8".
 - 7. 2 ½": Maximum span, 108"; minimum rod size, 3/8".
 - 8. 3": Maximum span, 10'-0"; minimum rod size, 3/8".
 - 9. 4": Maximum span, 12'-0"; minimum rod size, ½".
- D. Support multi-floor 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, specialties, and receivers. 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. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers. If vacuum holds for 12 hours, system is ready for charging.
 2. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.
 3. 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 controllers to the system design temperature.

END OF SECTION 232300

SECTION 233113 - METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Provisions of the Contract and of the Contract Documents apply to this Section.

1.2 PERFORMANCE REQUIREMENTS

- A. Seal all ducts to seal class A as defined in SMACNA's HVAC Duct Construction Standards - Metal and Flexible, Third Edition 2005:
 - 1. Seal all longitudinal joints.
 - 2. Seal all transverse joints.
 - 3. Seal all penetrations.
- B. Seal Class: A
- C. Duct Construction: 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, Third Edition 2005" and performance requirements and design criteria indicated in "Duct Schedule" Article.
- D. Liner Airstream Surfaces: Liner surfaces in contact with the airstream shall comply with ASHRAE 62.1-2007, paragraph 5.5.
- E. Cleanliness: All factory fabricated duct shall be cleaned with a non-toxic, biodegradable cleaner/degreaser and shall be shrink wrapped prior to shipment.

1.3 ABBREVIATIONS

- A. BAS Building Automation System
- B. NRTL Nationally Recognized Testing Laboratory
- C. SMACNA Sheet Metal and Air Conditioning Contractors' National Association
- D. WC Water Column

1.4 DEFINITIONS:

- A. Duct System: For the purposes of this section "duct system" shall mean all metal supply, return, and exhaust duct and fittings between the air moving device and the space.
- B. Low Pressure: Plus two (2.0) inches WC to minus one (1.0) inches WC
- C. Medium Pressure: More than two (2.0) inches WC to plus ten (10.0) inches WC or more than minus one (1.0) inch to minus ten (10.0) inches WC
- D. High Pressure: More than plus or minus ten (10.0) inches WC.

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1.5 SUBMITTALS

- A. Product Data / Documentation: For each of the following:
1. Sheet metal thicknesses.
 2. Liners and adhesives.
 3. Pre-manufactured ductwork.
 4. Sealants and gaskets.
 5. VOC content for adhesives and sealants.
- B. CAD-generated Shop Drawings:
1. Provide coordination shop drawings with all trades for entire building including kitchen, laundry and water/mechanical rooms. Include
 2. Show fabrication and installation details for metal ducts.
 3. 1/4" = 1'-0" scale minimum including duct layout indicating sizes and pressure classes for the following areas:
 - a. Areas indicated on the drawings at 1/4" = 1'-0" scale.
 - b. Areas where sections are cut.
 - c. Finished spaces with exposed ductwork.
 - 1) Exceptions:
 - a) Janitors closets
 - b) Storage Rooms
 - c) Receiving Areas
 - 2) Include:
 - a) Plans, elevations and sections.
 - b) Elevations of top and bottom of ducts.
 - c) Dimensions of main duct runs from building grid lines.
 4. 3/4" = 1'-0" scale minimum for the following:
 - a. Hangers and supports, including methods for duct and building attachment, vibration isolation.
 - b. Duct accessories, including access doors and panels.
 - c. Equipment installation based on approved equipment submittals.
 - d. Penetrations through fire-rated and other partitions.
 - e. Fittings.
 - f. Components.

1.6 QUALITY ASSURANCE

- A. Provide work in compliance with applicable Building Code requirements.
- B. Welding Qualifications: Qualify procedures and personnel according to the following:
- C. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
- D. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum," for aluminum supports.
- E. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.
- F. ASHRAE Compliance: Comply with applicable requirements in ASHRAE 62.1-2007, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."

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- G. ASHRAE/IESNA Compliance: Comply with applicable requirements in ASHRAE/IESNA 90.1-2007, Section 6.4.4 - "HVAC System Construction and Insulation."
- H. Mockups (Contractor's option in lieu of 3"=1'-0" details):
 - 1. Before installing duct systems, build mockups. Build mockups to comply with the following requirements, using materials indicated for the completed Work:
 - 2. Three transverse joints.
 - 3. One Reinforced section with 3 reinforcements.
 - 4. One of each type; attachments to other work.
 - 5. Two typical flexible duct or flexible-connector connections.
 - 6. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

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, Third Edition 2005" 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, Third Edition 2005," Figure 2-1, "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, Third Edition 2005."
- C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible, Third Edition 2005," Figure 2-2, "Rectangular Duct/Longitudinal Seams" 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, Third Edition 2005."
- 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, Third Edition 2005," Chapter 4, "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, Third Edition 2005."

2.2 DOUBLE-WALL RECTANGULAR DUCTS AND FITTINGS (PERFORATED LINER)

- A. Manufacturers:
 - 1. McGill AirFlow LLC.
 - 2. MKT Metal Manufacturing
 - 3. Sheet Metal Connectors, Inc.
- B. Rectangular Ducts: Fabricate ducts with indicated dimensions for the inner duct.

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- C. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible, Third Edition 2005" based on indicated static-pressure class unless otherwise indicated.
 - D. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible, Third Edition 2005," Figure 2-1, "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, Third Edition 2005."
 - E. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible, Third Edition 2005," Figure 2-2, "Rectangular Duct/Longitudinal Seams" 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, Third Edition 2005."
 - F. 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. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
 - 2. Coat insulation with antimicrobial coating.
 - 3. Cover insulation with polyester or Mylar film complying with UL 181, Class 1.
 - G. Inner Duct: Minimum 22-gauge perforated galvanized sheet steel having 3/32-inch- diameter perforations, with overall open area of 23 percent.
 - H. Formed-on Transverse Joints (Flanges): Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible, Third Edition 2005," 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, Third Edition 2005."
 - I. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible, Third Edition 2005," 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, Third Edition 2005."
- 2.3 LOW PRESSURE SINGLE-WALL ROUND DUCTS AND FITTINGS –CONCEALED
- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible, Third Edition 2005," Chapter 3, "Round, Oval, and Flexible Duct," based on specified static-pressure class unless otherwise indicated.
 - B. Snap-Lock Round Pipe
 - 1. Meet SMACNA Class 3 Leakage standards and SMACNA Seal Class A with external, mastic duct sealant. Provide ASTM A653 galvanized steel, 26 gauge, G-60 coating. Product shall meet pressure rating of -1" wg to +2" wg.
 - 2. Available Manufacturers:
 - a. GreenSeam Industries (GreenSeam Plus)
 - C. Manufacturers:

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1. Eastern Sheet Metal.
 2. Hamlin Sheet Metal.
 3. Linx Industries - Lindab.
 4. McGill AirFlow LLC.
 5. MKT Metal Manufacturing
 6. Semco, Inc.
 7. Sheet Metal Connectors, Inc.
 8. Spiral Manufacturing Co., Inc.
- D. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible, Third Edition 2005," Figure 3-1, "Round Duct Transverse Joints"
1. Transverse Joints in Ducts Equal to or Larger Than 48" in Diameter Flanged.
 2. Gasketed, EPDM, self-sealing Joints such as Eastern Tight or Spiro Safe may be used for ducts smaller than 48" in diameter.
 3. Flanges may be substituted in ducts smaller than 48" in diameter.
- E. Duct support intervals, and other provisions: In accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible, Third Edition 2005."
- F. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible, Third Edition 2005," Figure 3-2, "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, Third Edition 2005."
- G. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible, Third Edition 2005," Figure 3-5, "90° Tees and Laterals," and Figure 3-6, "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, Third Edition 2005." Adjustable elbows are not permitted.
- H. All round duct shall not be less than 26-gauge.
- 2.4 MEDIUM PRESSURE SINGLE-WALL ROUND AND FLAT OVAL DUCTS AND FITTINGS
–CONCEALED
- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible, Third Edition 2005," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.
- B. Manufacturers:
1. Eastern Sheet Metal.
 2. Hamlin Sheet Metal.
 3. Linx Industries - Lindab.
 4. McGill AirFlow LLC.
 5. MKT Metal Manufacturing
 6. Semco, Inc.
 7. Sheet Metal Connectors, Inc.
 8. Spiral Manufacturing Co., Inc.

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- C. Flat-Oval Ducts: Dimensions are the inside duct width (major dimension) and inside diameter of the round sides connecting the flat portions of the duct (minor dimension) of the inner duct.
- D. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible, Third Edition 2005," Figure 3-1, "Round Duct Transverse Joints"
 - 1. Transverse Joints in Ducts Equal to or Larger Than 48" in Diameter: Flanged.
 - 2. Gasketed, EPDM, self-sealing Joints such as Eastern Tight or Spiro Safe may be used for ducts smaller than 48" in diameter.
 - 3. Flanges may be substituted in ducts smaller than 48" in diameter.
- E. Duct support intervals, and other provisions: In accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible, Third Edition 2005."
- F. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible, Third Edition 2005," 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, Third Edition 2005."
- G. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible, Third Edition 2005," Figure 3-5, "90° Tees and Laterals," and Figure 3-6, "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, Third Edition 2005." Adjustable elbows are not permitted.
- H. All seam types in Figure 3-2 are acceptable where approved by SMACNA.
- I. All round duct shall not be less than 26-gauge.

2.5 LOW PRESSURE SINGLE-WALL ROUND DUCTS AND FITTINGS -EXPOSED

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible, Third Edition 2005," Chapter 3, "Round, Oval, and Flexible Duct," "FIGURE 3-2 ROUND DUCT LONGITUDINAL SEAMS" "SPIRAL SEAM RL-1" to plus-or-minus 10" WC unless otherwise indicated.
- B. Manufacturers:
 - 1. Eastern Sheet Metal.
 - 2. Hamlin Sheet Metal.
 - 3. Linx Industries - Lindab.
 - 4. McGill AirFlow LLC.
 - 5. MKT Metal Manufacturing
 - 6. Semco, Inc.
 - 7. Sheet Metal Connectors, Inc.
 - 8. Spiral Manufacturing Co., Inc.
- C. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible, Third Edition 2005," Figure 3-1, "Round Duct Transverse Joints"

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- D. Static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible, Third Edition 2005." And the following:
 - 1. Transverse Joints in Ducts Equal to or Larger Than 48" in Diameter or Flat Oval with a Major Dimension Equal to or Larger Than 48": Flanged.
 - 2. Gasketed, EPDM, self-sealing Joints such as Eastern Tight or Spiro Safe may be used for ducts smaller than 48" in diameter.
 - 3. Flanges may be substituted in ducts smaller than 48" in diameter.
- E. Longitudinal Seams: Duct shall be spiral according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible, Third Edition 2005," Figure 3-2, "Round Duct Longitudinal Seams"
- F. Tees and Laterals: Tees and laterals shall be created with fittings. Fabricate fittings according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible, Third Edition 2005." Adjustable elbows are not permitted.
- G. Static-pressure class: Applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible, Third Edition 2005."
- H. Longitudinal seams shall be spiral type.
- I. All round duct shall not be less than 26-gauge.

2.6 MEDIUM PRESSURE SINGLE-WALL ROUND DUCTS AND FITTINGS -EXPOSED

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible, Third Edition 2005," Chapter 3, "Round, Oval, and Flexible Duct," "FIGURE 3-2 ROUND DUCT LONGITUDINAL SEAMS" "SPIRAL SEAM RL-1" to plus-or-minus 10" WC unless otherwise indicated.
- B. Manufacturers:
 - 1. Eastern Sheet Metal.
 - 2. Hamlin Sheet Metal.
 - 3. Linx Industries - Lindab.
 - 4. McGill AirFlow LLC.
 - 5. MKT Metal Manufacturing
 - 6. Semco, Inc.
 - 7. Sheet Metal Connectors, Inc.
 - 8. Spiral Manufacturing Co., Inc.
- C. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible, Third Edition 2005," Figure 3-1, "Round Duct Transverse Joints"
- D. Static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible, Third Edition 2005." And the following:
 - 1. Transverse Joints in Ducts Equal to or Larger Than 48" in Diameter or Flat Oval with a Major Dimension Equal to or Larger Than 48": Flanged.

2. Gasketed, EPDM, self-sealing Joints such as Eastern Tight or Spiro Safe may be used for ducts smaller than 48" in diameter.
 3. Flanges may be substituted in ducts smaller than 48" in diameter.
- E. Longitudinal Seams: Duct shall be spiral according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible, Third Edition 2005," Figure 3-2, "Round Duct Longitudinal Seams"
- F. Tees and Laterals: Tees and laterals shall be created with fittings. Fabricate fittings according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible, Third Edition 2005." Adjustable elbows are not permitted.
- G. Static-pressure class: Applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible, Third Edition 2005."
- H. Longitudinal seams shall be spiral type.
- I. All round duct shall not be less than 26-gauge.

2.7 SHEET METAL MATERIALS

- A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible, Third Edition 2005" 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.
 2. Finishes for Surfaces Exposed to View: Mill phosphatized.
- C. Aluminum Sheets: Comply with ASTM B 209 Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.
- D. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
- E. 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 minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.8 DUCT LINER

- A. For double wall duct: Not required. All other duct: Provide where indicated.
- B. Flexible Elastomeric Duct Liner: Preformed, cellular, closed-cell, sheet materials complying with ASTM C 534, Type II, Grade 1; and with NFPA 90A or NFPA 90B. Foam shall contain or be coated with EPA-approved or EPA-registered antimicrobial additive or paint.
1. Manufacturers:
 - a. Aeroflex USA, Inc.

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- b. Armacell LLC.
 - c. K-Flex USA.
- 2. Maximum Thermal Conductivity: 0.25 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature when tested according to ASTM C 518.
 - 3. 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.
 - 4. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
- C. Natural-Fiber Duct Liner: 85 percent cotton, 10 percent borate, and 5 percent polybinding fibers, treated with a microbial growth inhibitor and complying with NFPA 90A or NFPA 90B.
- 1. Manufacturers:
 - a. Ductmate Industries, Inc.
 - 2. Maximum Thermal Conductivity: 0.24 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature when tested according to ASTM C 518.
 - 3. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to ASTM E 84; certified by an NRTL.
 - 4. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
- D. Insulation Pins and Washers:
- 1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
 - 2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick galvanized steel; with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
- E. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 7-11, "Flexible Duct Liner Installation."
- 1. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
 - 2. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
 - 3. Butt transverse joints without gaps, and coat joint with adhesive.
 - 4. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
 - 5. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and dimensions of standard liner make longitudinal joints necessary.
 - 6. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm.

7. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.
 8. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:
 - a. Fan discharges.
 - b. Intervals of lined duct preceding unlined duct.
 - c. Upstream edges of transverse joints in ducts where air velocities are higher than 2500 fpm or where indicated.
- F. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

2.9 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.
 1. Materials: Certified by a NRTL.
- B. Tape sealing systems are not permitted.
- 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, 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.
 10. Indoor applications: Sealant with VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 11. Maximum Static-Pressure Class: 10-inch wg, positive or negative.
 12. Service: Indoor or outdoor.
 13. Substrate: Compatible with galvanized sheet steel, 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.
 6. Indoor applications: Sealant with VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

- E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

2.10 HANGERS AND SUPPORTS

- A. Hanger Rods: Galvanized, all-thread.
- B. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible, Third Edition 2005," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."
- C. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.
- D. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.
- E. 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.
- F. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- G. 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.

2.11 RESIDENTIAL DRYER VENTING ACCESSORIES

- A. Wall Vent: Stainless steel or Aluminum body with backdraft damper. Factory paint to tan color matching precast concrete façade.
 - 1. In-O-Vate Technologies, Inc. – Dryer Wall Vent
 - 2. American Aldes – Standard Dryer Wall Hood
 - 3. Approved equal for dryer vent terminations through exterior walls.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. 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 by Architect in writing.
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible, Third Edition 2005" unless otherwise indicated.
- C. Install ducts with fewest possible joints.
- D. Install factory-fabricated fittings for changes in direction, size, and shape and for branch connections.

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- E. Unless otherwise indicated, install ducts vertically or horizontally, and parallel or perpendicular to building lines.
- F. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building. Maintain clearances for equipment maintenance.
- G. Install ducts with a clearance of 1 inch, plus allowance for installation of insulation at specified thickness.
- H. Do not route ducts through transformer vaults, electrical equipment rooms, elevator equipment rooms or electrical enclosures.
- I. 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.
- J. Provide fire dampers where ducts pass through fire-rated interior partitions, fire-rated exterior walls, fire-rated floor assemblies, or fire-rated shaft enclosures.
- K. Protect duct interiors from moisture, construction debris, dust, and other foreign materials. Comply with SMACNA's "Duct Cleanliness for New Construction Guidelines."

3.2 PROTECTION OF WALL AND FLOOR PENETRATIONS OF NON-RATED ASSEMBLIES

- A. Where ducts penetrate non-fire-resistance-rated wall or floor assemblies, protect the penetration with one of the following:
 - 1. For a duct that connects not more than two stories vertically, protect the annular space around the penetrating duct with an approved, noncombustible material that resists the free passage of flame and the products of combustion.
 - 2. For a duct that connects not more than three stories, protect the annular space around the penetrating duct with an approved, noncombustible material that resists the free passage of flame and the products of combustion and a fire damper at each floor line.
 - 3. For ducts that penetrate a smoke partition without a smoke damper, protect the annular space around the penetrating duct with an approved, non-combustible materials that resists the free passage of flame and the products of combustion.
 - 4. For ducts that penetrate a non-rated wall, protect the annular space around the penetrating duct with an approved, non-combustible materials that resists the free passage of flame and the products of combustion.

3.3 INSTALLATION OF EXPOSED DUCTWORK

- A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.
- B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.
- C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding. Do not weld or grind lined ductwork.

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- D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of duct, fittings, hangers, supports, accessories, and air outlets.
- E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.4 DUCT SEALING

- A. Seal all ducts to seal class A as defined in SMACNA's HVAC Duct Construction Standards - Metal and Flexible, Third Edition 2005:
 - 1. Seal all longitudinal joints.
 - 2. Seal all transverse joints.
 - 3. Seal all penetrations.

3.5 HANGER AND SUPPORT INSTALLATION

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible, Third Edition 2005," Chapter 5, "Hangers and Supports."
- B. Building Attachments: Unless indicated otherwise, provide 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. Do not use powder-actuated concrete fasteners for lightweight-aggregate concrete or for slabs less than 4 inches thick.
- C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible, Third Edition 2005," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.
- D. Hangers Exposed to View: Threaded rod and channel supports.
- E. Support vertical ducts with channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor or at a maximum interval of 18 feet.
- 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.

3.6 CONNECTIONS

- A. Make connections to equipment with flexible connectors.
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible, Third Edition 2005" for branch, outlet, inlet, and terminal unit connections unless otherwise indicated.

3.7 PAINTING

- A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply two coats of flat black, latex paint over a compatible galvanized-steel primer.

3.8 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Visually inspect, for proper seal application, all ductwork not tested prior to insulation application. Prepare inspection report.
- C. Prepare and submit test and inspection reports.

3.9 START UP

- A. Air Balance: Comply with requirements in Division 01 Section "Testing, Adjusting, and Balancing for HVAC."

3.10 DUCT SCHEDULE

- A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:
- B. Double-Wall Duct Interstitial Insulation:
 - 1. Supply Air Ducts: 1" thickness.
- C. Rectangular, Round or Flat Oval Duct Liner Thickness.
 - 1. Supply Air Ducts: 1-1/2" thickness and minimum R=5.0.
 - 2. Return/ Transfer Air Ducts: 1" thickness and minimum R=3.
- D. Rectangular Ductwork: Provide liner on ductwork systems indicated below and where indicated on drawings.
 - 1. Fan Powered VAV boxes return ductwork from return grille to unit connection.
 - 2. Fan Powered VAV boxes serving sound sensitive spaces on supply ductwork, discharge of VAV box to point indicated on drawings but at least 10' downstream.
 - 3. RTU-1 return ductwork.
 - 4. RTU-1 supply air ductwork from unit outlet to points indicated on drawings but at least 15' downstream.
 - 5. DOAU-1 supply and return ductwork, from unit connections to 10' downstream.
- E. Elbow Configuration:
 - 1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible, Third Edition 2005," Figure 4-2, "Rectangular Elbows."
 - a. Velocity less than 1500 fpm or lower:
 - 1) Radius Type RE 1. Centerline radius = $3W/2$.
 - 2) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible, Third Edition 2005," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
 - 3) Transfer ducts indicated with mitered elbows do not require turning vanes.
 - b. Velocity 1500 fpm or Higher:
 - 1) Radius Type RE 3. Centerline radius = $3w/2$ and three vanes.

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- 2) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible, Third Edition 2005," Figure 2-3, "Vanes 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, Third Edition 2005," Figure 3-4, "Round Duct Elbows."
 - a. Minimum centerline radius-to-diameter ratio shall be 1.5 with a maximum of 5 Elbow Segments. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible, Third Edition 2005," Table 3-1, "Mitered Elbows." Elbows with less than a 90 degree change of direction shall have segments per Table 3-1 in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible, Third Edition 2005".
 - b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped, segmented, spiral or pleated. Adjustable elbows not acceptable.
 - c. Round Elbows, 14 Inches and Larger in Diameter: Standing seam, segmented, or spiral.
 3. Flat Oval Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible, Third Edition 2005," Figure 3-7, "Flat Oval Ducts" for elbows.
- F. Branch Configuration:
1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible, Third Edition 2005," Figure 4-6, "Branch Connections."
 - a. Rectangular Main to Rectangular Branch: 45-degree entry.
 - b. Rectangular Main to Round Branch: Conical or bell mouth. No flanged or spin-in fittings permitted.
 2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible, Third Edition 2005," Figure 3-6, "Conical Tees."
 - a. Conical fitting.
 - b. Conical saddle taps.
 - c. No 90 degree taps or 90 degree saddle taps permitted.
- G. Divided Flow Branches:
1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible, Third Edition 2005," Figure 4-5 Divided Flow Branches."
- 3.11 Duct Pressure Classes:
- A. Supply ducts from rooftop units to terminal units: 3 inches WC.
 - B. Supply, return and exhaust ducts from dedicated outside air unit to air terminals: 1 inch WC.
 - C. Supply ducts from terminal units to air terminals: 1 inch WC.
 - D. Return ducts: 1 inch WC.
 - E. Exhaust ducts: 1 inch WC.

END OF SECTION 233113

SECTION 233300 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Provisions of the Contract and of the Contract Documents apply to this Section.

1.2 SUBMITTALS

- A. Product Data: For the following:
1. Radius forming braces
 2. Volume dampers.
 3. Motorized control dampers.
 4. Backdraft dampers
 5. Fire dampers.
 6. Ceiling radiation dampers.
 7. Smoke dampers.
 8. Combination fire-smoke dampers.
 9. Flange connectors.
 10. Turning vanes.
 11. Duct-mounted access doors.
 12. Duct access panel assemblies.
 13. Flexible connectors.
 14. Flexible ducts.
- B. Wiring Diagrams: For power, signal, and control wiring.
- C. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.3 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.
- C. Comply with SMACNA standards for manual airflow regulators (dampers).

1.4 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. Minimum 1 of each type used.

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. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable duct installation methods unless otherwise indicated.
- C. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
 - 1. Galvanized Coating Designation: G90.
 - 2. Exposed-Surface Finish: Mill phosphatized.
- D. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304, and having a NO 2 finish for concealed ducts and NO 4 finish for exposed ducts.
- E. Aluminum Sheets: Comply with ASTM B 209, Alloy 3003, temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.
- F. Extruded Aluminum: Comply with ASTM B 221, Alloy 6063, Temper T6.
- G. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.
- H. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches; compatible materials for aluminum and stainless-steel ducts.

2.2 RADIUS FORMING BRACES

- A. Available manufacturers:
 - 1. Titus, FlexRight (Basis of Design)
 - 2. Flexible Technologies, Inc., Thermaflex Division, FlexFlow
 - 3. Hart & Cooley, Smart Flow Elbow
- B. General: UL-2043 listed or NRTL approved product constructed of metal or plastic manufactured for use with flexible duct to form a kink free elbow using the flexible duct. Any flexible duct used in forming the elbow shall be included in the maximum permitted length. Resulting flexible duct shall comply with SMACNA HVAC Duct Construction Standards.
- C. Duct Size: 6" through 16" in diameter.
- D. Inside (Bend) Radius: Minimum of one duct diameter along centerline.
- E. Attachments: Plastic zip ties or stainless steel worm gear clamps.
- F. Support to Overhead: Shall meet SMACNA requirements. Use of specified attachments for support shall not be permitted.

2.3 MANUAL VOLUME DAMPERS

- A. Standard, Steel, Manual Volume Dampers:

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1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Rossi HVAC hardware
 2. Suitable for horizontal or vertical applications.
 3. Locking Hardware Component: Everlock damper handle by Rossi.
 - a. Bracket: Cold Rolled Steel (ASTM A-1008), 18-gauge nominal thickness. Single cut and formed bracket for use with 1.5" or 2.0" insulation wrapping or any other such stand-off applications. Finished with a white Chromate plating process.
 - b. Handle and Thumb Trigger: Polyamide 66 (PA66), flame retardant, glass reinforced, "Zytel," from Dupont.
 - c. Compression Spring: Stainless steel type 302-OD 0.25 wire 0.026 free length of 7/8" (0.875").
 - d. Retaining Spring: Ext. self-lock TX-75ST-ZF Carbon Steel SAE 1074 with Zink Bright Plating. C-Scale Rockwell Hardness 47 to 51.
 4. Blades (or Discs):
 - a. 4" to 16" Diameter single blade (or disc). ASTM-A527 LFO G90, 22 gauge reinforced to equal strength of 20-gauge material.
3/8" Full length bar fits through formed channel in center of damper blade.
 5. Bars: 3/8" square Aluminum bar
 6. Bearings:
 - a. Snap-in bearings by Rossi for medium and low pressure systems. Polyamide 66 (PA66), Flame Retardant, Glass Reinforced, "Zytel" by Dupont.
 - b. Clip-on bearings by Rossi for higher pressure systems. Polyamide 66 (PA66), Flame Retardant, Glass Reinforced, "Zytel" by Dupont.
 - c. B-Lined bearings by Rossi for lined duct. Polyamide 66 (PA66), Flame Retardant, Glass Reinforced, "Zytel" by Dupont.
- B. Damper Hardware for Other Dampers:
1. Locking Hardware Component: Everlock damper handle by Rossi.
 - a. Bracket: Cold Rolled Steel (ASTM A-1008), 18-gauge nominal thickness of 0.0478 with tolerance range of 0.0438 to 0.0518. Single cut and formed bracket for use with 1.5" or 2.0" insulation wrapping or any other such stand-off applications. Finished with a white Chromate plating process which provides durable corrosion resistance. Auto Plating ASTM B-633 Type II (white) class FE/ZN8 or SC2 Thickness of 0.0003.
 - b. Handle and Thumb Trigger: Polyamide 66 (PA66), Flame Retardant, Glass Reinforced, "Zytel," by Dupont.
 - c. Compression Spring: Stainless Steel Type 302-OD 0.25 wire 0.026 free length of 7/8" (0.875").

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- d. Retaining Spring: Ext. Self-Lock TX-75ST-ZF Carbon Steel SAE 1074 with Zink Bright Plating. C-Scale Rockwell Hardness 47 to 51.

C. Steel, Manual Volume Dampers:

1. Manufacturers:

- a. Air Balance Inc.; a division of Mestek, Inc.
- b. American Warming and Ventilating; a division of Mestek, Inc.
- c. Elgen Manufacturing.
- d. Greenheck Fan Corporation.
- e. McGill AirFlow LLC.
- f. Nailor Industries.
- g. PCI Industries - Pottorff
- h. Ruskin Company.

2. Standard leakage rating, with linkage outside airstream.

3. Suitable for horizontal or vertical applications.

4. Frames:

- a. Hat-shaped, 0.094-inch thick galvanized or 0.05-inch stainless-steel, match duct material.
- 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. Opposed-blade design.
- c. Stiffen damper blades for stability.
- d. Galvanized or stainless-steel channels, match duct material.

6. Blade Axles: Galvanized steel or stainless steel. Dampers over 12" width/diameter shall include continuous axles. Dampers 12" and less may have non-continuous axles. Comply with SMACNA HVAC Duct Construction Standards Metal and Flexible – Third Edition Figure 7-4.

7. Bearings:

- a. Molded synthetic. Provide bearing at both duct wall penetrations.

8. Tie Bars and Brackets: Galvanized steel.

2.4 CURTAIN TYPE FIRE DAMPERS (1½ HOUR)

A. Manufacturers:

- 1. Cesco Products; a division of Mestek, Inc.
- 2. Greenheck Fan Corporation.
- 3. Johnson Controls, Inc.
- 4. Nailor Industries, Inc.
- 5. PCI Industries - Pottorff

- 6. Ruskin Company.
 - B. Type: Dynamic; rated and labeled according to UL 555 by a NRTL.
 - C. Pressure: Dampers shall have a minimum UL 555 differential pressure rating of 4 in. WG
 - D. Velocity: Dampers shall have a minimum UL 555 velocity rating of 2000 FPM.
 - E. Fire Rating: 1½ hours.
 - F. Frame: Curtain type with blades outside the airstream unless otherwise indicated; fabricated of roll-formed galvanized steel; with mitered and interlocking corners.
 - G. Sleeve: Factory-installed, galvanized sheet steel.
 - 1. Minimum Thickness: Per UL requirements.
 - 2. Minimum Length: To suit application.
 - H. Mounting Orientation: Vertical or horizontal as indicated.
 - I. Blades: Roll-formed, interlocking galvanized sheet steel. In place of interlocking blades, full-length galvanized-steel blade connectors may be used.
 - J. Horizontal Dampers: Include stainless-steel closure spring.
 - K. Fusible Link: Replaceable, 165 deg F rated.
 - L. Retaining Angles: Damper shall be supplied with factory retaining angles sized to provide installation overlap in accordance with the manufacturer's UL listing

2.5 MULTI BLADE FIRE DAMPERS (1½ HOURS)

- A. Manufacturers:
 - 1. Cesco Products; a division of Mestek, Inc.
 - 2. Greenheck Fan Corporation.
 - 3. Johnson Controls, Inc.
 - 4. Nailor Industries, Inc.
 - 5. PCI Industries - Pottorff
 - 6. Ruskin Company.
- B. Type: Dynamic; rated and labeled according to UL 555 by an NRTL.
- C. Pressure: Dampers shall have a minimum UL 555 differential pressure rating of 4 in. WG
- D. Velocity: Dampers shall have a minimum UL 555 velocity rating of 4000 FPM.
- E. Fire Rating: 1½ hours.
- F. Frame: Multiple-blade type; fabricated of galvanized steel; with mitered and interlocking corners.
- G. Sleeve: Factory-installed, galvanized sheet steel.
 - 1. Minimum Thickness: Per UL requirements.
 - 2. Minimum Length: To suit application.
- H. Mounting Orientation: Vertical or horizontal.
- I. Blades: Blades: Damper blades shall be galvanized steel. Each blade shall be symmetrical relative to its axle pivot point, presenting identical performance characteristics with air flowing

in either direction. Provide symmetrical blades of varying size as required to completely fill the damper opening.

- J. Blade Stops: Locate blade stops at top and bottom of damper frame. They shall occupy no more than ½" of the damper opening area.
- K. Bearings: Axle bearings shall be sintered bronze.
- L. Horizontal Dampers: Include stainless-steel closure spring.
- M. Fusible Link: Replaceable, 165 deg F rated.
- N. Retaining Angles: Damper shall be supplied with factory retaining angles sized to provide installation overlap in accordance with the manufacturer's UL listing.

2.6 SMOKE DAMPERS

- A. Manufacturers:
 - 1. Cesco Products; a division of Mestek, Inc.
 - 2. Greenheck Fan Corporation. (Basis of design, provide model SMD-301)
 - 3. Johnson Controls, Inc.
 - 4. Nailor Industries, Inc.
 - 5. PCI Industries - Pottorff
 - 6. Ruskin Company.
- B. General Requirements: Rated and labeled according to UL 555S by an NRTL.
- C. Closing rating in ducts up to 4-inch WC static pressure class and minimum 3000 FPM velocity.
- D. Smoke Detector: Provide factory-mounted and -wired smoke detector with smoke damper or provide field-mounted smoke detector installed within five feet of damper. Detector shall be a listed and labeled. Provide normally open contacts for monitoring by the fire alarm system.
 - 1. Minimum Velocity: Zero feet per minute.
 - 2. Maximum Velocity: Three thousand feet per minute minimum.
- E. Configuration: Multiple-blade type; fabricated with roll-formed, 0.034-inch- thick galvanized steel; with mitered and interlocking corners.
- F. Blades: Roll-formed, horizontal, interlocking, 0.07 inch thick, galvanized sheet steel air foil.
- G. Blade edge seals: Silicone rubber.
- H. Blade linkage: Out of air stream.
- I. Leakage: Class II.
- J. Mounting Sleeve: Factory-installed galvanized sheet steel; length to suit wall or floor application.
- K. Damper Motor: Two-position.
- L. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."
 - 1. Motor Sizes: Minimum size shall be large enough so driven load will not require motor to operate in service factor.

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2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Section "Building Automation System" and Division 28 Sections.
3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
4. Spring-Return Motors: Equip with an integral spiral-spring mechanism. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 IN x LBF and breakaway torque rating of 150 IN x LBF.
5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at 0 degrees F.

M. Accessories:

1. Auxiliary switches for position indication.
2. Damper mounted momentary test switch.

2.7 COMBINATION FIRE AND SMOKE DAMPERS

A. Manufacturers:

1. Cesco Products; a division of Mestek, Inc.
2. Greenheck Fan Corporation. (Basis of design, provide model FSD-331)
3. Johnson Controls, Inc.
4. Nailor Industries, Inc.
5. PCI Industries - Pottorff
6. Ruskin Company.

B. Type: Dynamic; rated and labeled according to UL 555 and UL 555S by a NRTL.

C. Closing rating in ducts up to 4-inch WC static pressure class and minimum 2000 FPM velocity.

D. Fire Rating: 3 hours or as indicated.

E. Smoke Detector: Provide factory-mounted and -wired smoke detector with smoke damper or provide field-mounted smoke detector installed within five feet of damper. Detector shall be a listed and labeled. Provide normally open contacts for monitoring by the fire alarm system.

1. Minimum Velocity: Zero feet per minute.
2. Maximum Velocity: Three thousand feet per minute minimum.

F. Configuration: Multiple-blade type; fabricated with roll-formed, 0.034-inch- thick galvanized steel; with mitered and interlocking corners.

G. Heat-Responsive Device: Electric resettable link and switch package, factory installed and rated. Provide damper position indicator to indicate open & closed positions.

H. Frame: Multiple-blade type; fabricated with roll-formed, 0.034-inch- thick galvanized steel; with mitered and interlocking corners.

I. Bearings: Sintered bronze.

J. Blades: Roll-formed, horizontal, interlocking, 0.07 inch thick, galvanized sheet steel air foil.

K. Blade edge seals: Silicone rubber.

L. Blade linkage: Out of air stream.

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- M. Leakage: Class II.
- N. Mounting Sleeve: Factory installed galvanized sheet steel; length to suit wall or floor.
- O. Damper Motors: Two-position.
- P. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."
 - 1. Motor Sizes: Minimum size shall be large enough so driven load will not require motor to operate in service factor.
 - 2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Section "Building Automation System" and Division 28 Sections.
 - 3. Spring-Return Motors: Equip with an integral spiral-spring mechanism. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 IN x LBF and breakaway torque rating of 150 IN x LBF.
 - 4. Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Provide motors with internal heaters to permit normal operation at 0 degrees F.
- Q. Accessories:
 - 1. Auxiliary switches for position indication.
 - 2. Damper mounted momentary test switch.

2.8 FLANGE CONNECTORS

- A. Available Manufacturers:
 - 1. Ductmate Industries, Inc.
 - 2. Nexus PDQ; Division of Shilco Holdings Inc.
 - 3. Hart & Cooley, Inc.
- B. Description: Add-on or roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.
- C. Material: Match connecting ductwork.
- D. Gauge: 18, 20, or 24 as recommended by manufacturer or match connecting ductwork.

2.9 MANUFACTURED TURNING VANES

- A. Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
- B. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-3, "Vaness and Vane Runners," and 2-4, "Vane Support in Elbows."
- C. Vane Construction: Single wall for ducts up to 48 inches wide and double wall for larger dimensions.

2.10 DUCT-MOUNTED ACCESS DOORS

- A. Available Manufacturers:

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1. Ductmate Industries, Inc.
 2. Flexmaster U.S.A., Inc.
 3. Greenheck Fan Corporation.
 4. Kees
 5. McGill AirFlow LLC.
- B. 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. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
 - d. 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 Square: No hinges and two sash locks.
 - b. Access Doors up to 18 Inches Square: Two hinges and two sash locks.
 - c. Access Doors up to 24 by 48 Inches: Three hinges and two compression latches with outside and inside handles.
 - d. Access Doors Larger Than 24 by 48 Inches: Four hinges and two compression latches with outside and inside handles.

2.11 FLEXIBLE CONNECTORS

- A. Do not use on smoke control/management fans. Install on all other fans and fan equipped units even when provided with internal isolation.
- B. Available Manufacturers:
1. Ductmate Industries, Inc.
 2. Duro Dyne Corporation.
 3. Ventfabrics, Inc.
 4. Hart & Cooley, Inc.
- C. Materials: Flame-retardant or noncombustible fabrics.
- D. Coatings and Adhesives: Comply with UL 181, Class 1.
- E. Connector: Factory fabricated with a fabric strip 3½ to 4½ inches wide attached to 2 strips of 2½ to 4½ inches wide, 23 to 25 gauge "0.0269 to .0209 inch thick" galvanized sheet steel, stainless sheet steel, or aluminum sheets. Provide metal compatible with connected ducts.
- F. Indoor System, Flexible Connector Fabric: Glass fabric double-coated with neoprene.
1. Minimum Weight: 26 oz/sq. yd.
 2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
 3. Service Temperature: Minus 40 to plus 200 deg F.
- G. Outdoor System, Flexible Connector Fabric: Glass fabric double-coated with weatherproof, synthetic rubber resistant to UV rays and ozone.
1. Minimum Weight: 24 oz/sq. yd.

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2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
3. Service Temperature: Minus 50 to plus 250 deg F.

H. Thrust Limiters:

1. Field fabricated cable restraints on equipment producing greater than 4.0" WC of positive pressure.
2. Field fabricated cable restraints as detailed. If not detailed; Provide restraint consisting of a 1/16 inch diameter vinyl coated steel cable at 24" maximum on center, attached to flange bolts on each side of flexible connector. Cable length shall be such that, when in tension, 1/2" of movement in the flexible connection is preserved. If flanges are not used, contractor may provide steel, stainless steel, or aluminum angles for attaching cables. Match duct material. Cables shall attach to screw or fastener holding angle to duct and shall be routed through a 3/16" diameter hole in the bracket offset approximately 1" from duct.
3. Direction of connector movement: Parallel with airflow, perpendicular to connector.

2.12 FLEXIBLE AIR DUCTS

A. Manufacturers:

1. Flexmaster U.S.A., Inc. (Basis of design, Provide Type 1M)
2. Thermaflex
3. Hart & Cooley, Inc.

B. Provide bead on connecting duct for sizes greater than 12" in diameter.

C. Maximum Length: 6'-0" unless noted otherwise.

D. Insulated, Flexible Duct: UL 181, Class 1 air duct with vinyl film supported by helically wound, spring-steel wire; fibrous-glass insulation; aluminized vapor-barrier film.

1. Pressure Rating: 10-inch WC positive and 1.0-inch WC negative.
2. Maximum Air Velocity: 5000 fpm.
3. Vapor Barrier Permeance: 0.05 perm
4. Temperature Range: Minus 10 to plus 160 deg F.
5. Insulation R-value: 6.0

E. Flexible Duct Connection Accessories:

1. Low pressure (Not up stream of terminal units):
 - a. Clamps: Nylon strap in sizes 3 through 20", to suit duct size.
 - b. Sheet metal screws: No
 - c. Liquid adhesive: No
 - d. Tape: Yes
2. Medium pressure (Up stream of terminal units):
 - a. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with worm-gear action in sizes 3 through 20 inches, to suit duct size.
 - b. Sheet metal screws: No
 - c. Liquid adhesive: Yes
 - d. Tape: Yes

2.13 ACCESSORY HARDWARE

- A. Temporary Test Holes: Drilled in duct as required.
- B. Permanent Test Holes: Cast iron, or cast aluminum, to suit adjacent material, including cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit wall + insulation thickness.
- C. Adhesives: High strength, quick setting, waterproof, and resistant to 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."
- 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. Radius Forming Braces:
 - 1. Connect flexible ducts to diffusers using a radius forming brace or rigid elbow. If using radius forming brace, deduct four duct diameters from the indicated maximum flexible duct length.
- D. Volume Dampers:
 - 1. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Locate at least two duct diameters from fittings and as far as possible from air outlets.
 - 2. 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.
 - 3. Set dampers to fully open position before testing, adjusting, and balancing.
 - a. Install steel volume dampers in steel ducts.
 - b. Install aluminum volume dampers in aluminum and stainless steel ducts.
- E. Install backdraft dampers at inlet of exhaust fans, exhaust ducts as close as possible to louver inlets, and where indicated.
- F. Install fire and smoke dampers where indicated according to UL listing and manufacturer's written instructions.
- G. Connect ducts to duct silencers with flexible duct connectors.
- H. Turning Vanes:
 - 1. Install turning vanes in all duct elbows larger than 12" in height or width.
 - 2. Exceptions:
 - a. Where prohibited by the applicable code, laws, ordinances or local requirements.
 - b. Where specifically eliminated by Contract.
- I. Provide remote damper operator where manual volume dampers are indicated above inaccessible ceilings.

J. Duct-Mounted Access Doors:

1. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
 - a. On both sides of duct coils.
 - b. Upstream or downstream of duct filters.
 - c. At outdoor air intakes and mixed air plenums.
 - d. Downstream of control dampers and backdraft dampers.
 - e. Adjacent to fire or smoke dampers to allow reset and reinstallation of fusible links. Access doors for fire or smoke dampers having fusible links shall be pressure relief access doors and shall have outward operation for access doors installed upstream of dampers and inward operation for access doors installed downstream of dampers.
 - f. Upstream or downstream of duct silencers.
 - g. At control devices requiring inspection.
 - h. Elsewhere as indicated.
2. Install access doors with swing against duct static pressure except at fire, smoke, and combination fire and smoke dampers.
3. Access Door Size: Largest of the following permitted by duct dimensions:
 - a. One-Hand or Inspection Access: 8 by 5 inches.
 - b. Two-Hand Access: 12 by 6 inches.
 - c. Head and Hand Access: 18 by 10 inches.
 - d. Head and Shoulders Access: 21 by 14 inches.
 - e. Body Access: 25 by 14 inches.
 - f. Body plus Ladder Access: 25 by 17 inches.
4. Label access doors to indicate purpose in accordance with Section 230553 "Identification for HVAC Piping and Equipment."

K. Flexible Connectors

1. Install flexible connectors to connect ducts to equipment- except smoke control/management equipment.
2. Where required, install thrust limiters at all flexible connectors consisting of a 1/16-inch diameter vinyl coated steel cable at 24" maximum on center, attached to flange bolts on each side of flexible connector. Cable length shall be such that, when in tension, 1/2" of movement in the flexible connection is preserved. If flanges are not used, provide steel, stainless steel, or aluminum angles for attaching cables. Match angle material to duct material. Cables shall attach to screw or fastener holding angle and shall be routed through a 3/16" diameter hole in the angle offset approximately 1" from duct.

L. Connect flexible ducts to metal ducts as follows:

1. Low pressure (Not upstream of terminal units):
 - a. Clamps: Install in accordance with manufacturer's recommendations.
 - b. Tape: Install in accordance with manufacturer's recommendations.
 - c. Cable Ties (18 lb. strength): Install in accordance with manufacturer's recommendations.

M. Flexible Ducts

1. Install flexible duct fully extended with no more than 1/2" compression or sag. Do not provide excess length for future relocation of components. Bends shall equal or exceed one duct diameter bend radius based on the inside duct diameter (no sharp corners or kinks). Tape and mastic for sealing flexible duct to metal fittings shall be listed and labeled to UL Standard 181B. Hanging straps, if used, shall include a saddle to avoid crimping the duct. For ducts 12 inches and smaller in diameter, provide a 3" wide saddle. For ducts larger than 12 inches in diameter, provide a 5" wide saddle.
 2. Connect supply ceiling diffusers and return grilles to low pressure supply and/or return ductwork where indicated on drawings with [five] feet maximum length of flexible duct. Provide a radius forming elbow to support flexible duct at diffuser connection unless noted otherwise. Flexible duct not permitted on exhaust systems.
- N. Install rooftop duct supports for all roof-mounted ductwork.

3.2 TESTING AND BALANCING

- A. Install permanent test holes at fan inlets and outlets within 6 inches of fan, where indicated, and where necessary for testing and balancing. Test holes not required at outlet of roof-mounted fans.
- B. Install temporary test hole plugs in temporary test holes. Repair insulation at temporary test holes.

3.3 FIELD QUALITY CONTROL

- A. Tests and Inspections:
 1. Operate dampers to verify full range of movement without interference.
 2. Inspect access doors. Verify that door can be opened and closed. Verify fire damper, and combination fire and smoke damper fusible links can be reset and changed. Verify fire damper, and combination fire and smoke damper doors open in the direction of air pressure (out on supply ducts and in on return and exhaust ducts).
 3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement, verify non-interference, and verify that the proper heat-response device is installed.
 4. Inspect elbows for turning vanes. Verify they are installed where required.
 5. Inspect turning vanes using access doors for proper and secure installation.
 6. Operate remote damper operators prior to ceiling installation to verify full range of movement of operator and damper. Verify no interference with damper movement.

END OF SECTION 233300

SECTION 233423 - HVAC POWER VENTILATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Provisions of the Contract and of the Contract Documents apply to this Section.

1.2 SUBMITTALS

- A. Product Data: Provide manufacturer's technical data for each ventilator including rated capacities, dimensions, required clearances, operating characteristics, mounting requirements, and furnished specialties and accessories. Provide power and control wiring diagrams. Also 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.
 - 6. Roof curbs with required slope and dimensions. Indicate shimming if required.
 - 7. Fan speed controllers.
- B. Operation and Maintenance Data: For ventilators to include in emergency, operation, and maintenance manuals.

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. AMCA Compliance: Fans shall have AMCA-Certified performance ratings and shall bear the AMCA-Certified Ratings Seal.
- C. UL Standards: Power ventilators shall comply with UL 705. Power ventilators for use for grease (kitchen) hood exhaust shall also comply with UL 762.

1.4 COORDINATION

- A. Coordinate size and location of structural-steel support members.
- B. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

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. Belts: One set for each belt-driven fan. Mark belt set with fan ID and turn over to owner's representative.

PART 2 - PRODUCTS

2.1 CENTRIFUGAL ROOF VENTILATOR(S) (DOWNBLAST)

- A. Manufacturers:
1. Acme Engineering & Manufacturing Corporation.
 2. Twin City Fan & Blower.
 3. Greenheck Fan Corporation.
 4. Loren Cook Company.
- B. Housing: Removable, spun-aluminum dome top and outlet baffle, or extruded-aluminum, rectangular top to direct discharge air downward.
- C. Base (Curb Cap): Square, one-piece, aluminum with venturi inlet cone.
- D. Hinged Sub-Base: Galvanized steel hinged arrangement permitting service and maintenance.
- E. Fan Wheels: Statically and dynamically balanced aluminum hub and wheel with backward-inclined blades matched to inlet cone.
- F. Belt Drives (where indicated in Fan Schedule): Comply with the following:
1. Provide drives sized for a minimum of 150% of driven horsepower.
 2. Provide resilient mounting to housing.
 3. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
 4. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
 5. Pulleys: Cast-iron, adjustable-pitch motor pulley.
 6. Fan and motor isolated from exhaust airstream
 7. Belt(s): Provide grip notch belt(s). Provide belt tensioner.
 8. Motors and drives:
 - a. Mount on vibration isolators.
 - b. Draw air for motor cooling into the motor compartment from an area free of discharge contaminants.
 - c. Make readily accessible for maintenance.
- G. Electrically-Commutated Motor (where direct drive indicated in Fan Schedule with VG in model number):
1. Motor enclosure: Open type.
 2. Motor shall be DC electronic commutation type motor (ECM).

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3. Motor shall be permanently lubricated, heavy duty ball bearing type to match with the fan load and prewired to the specific voltage and phase.
4. Internal motor circuitry to convert AC power supplied to fan to DC power to operate motor.
5. Motor shall be speed controllable down to 20% of full speed. Speed shall be controlled by either a potentiometer dial mounted at the motor or by a 0-10 VDC signal.

H. Overload (Running) Protection:

1. Provide motor overload protection as a requirement of this section.
2. Provide motor overload protection as recommended by the manufacturer
3. Comply with the Section 230513 "Motors for HVAC Equipment"

I. Wind-band: Join to curb-cap with leak-proof continuously welded seam.

J. Accessories:

1. Provide disconnect switch.
2. Provide removable, 1/2-inch mesh, aluminum or brass wire bird screen.
3. Provide parallel-blade dampers mounted in fan base or duct with normally closed electric actuator wired to close when fan stops. Actuator shall not be required to fail closed.
4. Motorized Backdraft Damper(s): Provide damper(s) with electric actuator(s) wired to close when fan stops and open with fan is on. Actuator voltage shall match fan motor voltage. Where matching actuator and fan voltage is not possible, fan manufacturer shall provide transformer to produce compatible voltage to actuator. Wiring of fan and backdraft damper actuator(s) shall be by Division 26.
5. Provide roof curb. Refer to Roof Curb Paragraph below.

2.2 MOTORS

A. Refer to section "Common Motor Requirements for HVAC Equipment."

B. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors.

1. Motor Sizes: Size shall be as indicated. If not indicated, provide motor large enough to drive load and avoid operation in service factor range above 1.0.
2. Controls: Provide controllers, electrical devices, and wiring to comply with requirements specified in Division 26 Sections.

C. Enclosure Type: Totally enclosed, fan cooled.

2.3 SOURCE QUALITY CONTROL

A. Certify sound-power level ratings according to 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.

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- B. Certify fan performance ratings, including flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating." Label fans with the AMCA-Certified Ratings Seal.

2.4 ROOF CURB:

- A. Minimum Height from Top of Roof Insulation for Non-Grease Fans: 12”.
- B. Slope: Match structure. Top of curb shall be level and each edge shall be flush with other edges on all sides.
- C. Curb Material: Match material of power ventilator located on roof curb.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install HVAC Power Ventilators level and plumb.
- B. Support suspended units from structure using threaded steel rods and elastomeric hangers having a static deflection of 0.5 inches.
- C. Install units with clearances for service and maintenance.
- D. Label units.

3.2 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- B. Tests and Inspections:
 - 1. Verify that Shipping blocking and bracing are removed.
 - 2. Verify that unit is secure and 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. For belt drive units 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 belts, adjust belt tension, and install belt guards.
 - 5. Adjust damper linkages & operators for proper damper operation.

6. Verify lubrication for bearings and other moving parts.
 7. Verify that manual and automatic volume control, fire, smoke, and fire/smoke dampers in connected ductwork systems are in a fully open position.
 8. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm.
 9. 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.
- C. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Prepare test and inspection reports.

3.3 TESTING, ADJUSTING, BALANCING, AND LUBRICATION

- A. Adjust damper linkages for proper damper operation.
- B. Comply with requirements in Section "Testing, Adjusting, and Balancing for HVAC".
- C. Replace fan and motor pulleys to achieve design airflow.
1. Disable automatic temperature-control operators, energize motor and adjust fan to required rpm.
 2. Measure and record RPM.
 3. Measure and record motor voltage and amperage.
- D. Re-lubricate bearings.

END OF SECTION 233423

SECTION 233600 - AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Provisions of the Contract and of the Contract Documents apply to this Section.

1.2 PERFORMANCE REQUIREMENTS

- A. Structural Performance: Hangers and supports shall withstand the effects of gravity and seismic loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and ASCE/SEI 7.
 - 1. Seismic Hazard Level A: Force to weight ratio = 0.48.
 - 2. Seismic Hazard Level B: Force to weight ratio = 0.30.
 - 3. Seismic Hazard Level C: Force to weight ratio = 0.15.

1.3 ABBREVIATIONS

- A. BAS Building Automation System.
- B. CFM Cubic Feet per Minute.
- C. ECM Electronically Commutated Motor.
- D. PSIG Pounds per Square Inch Gauge.
- E. PSC Permanent Split Capacitor
- F. SCR Silicon Controlled Rectifier.
- G. VA Volt Amps. (A measure of transformer power)

1.4 SUBMITTALS

- A. Pre-submittal Meeting: A representative of the manufacturer producing equipment being provided under this section of the specifications shall attend a meeting for the purpose of coordinating with the contractor performing work under section "Building Automation System". The meeting shall be held at a location of the Contractor's choosing. The Contractor shall arrange the meeting. Submittals shall be essentially complete at the time of the meeting so detailed coordination items can be discussed.

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- B. Product Data: For each type of the following products, including rated capacities, furnished specialties, sound-power ratings, and accessories.
 - 1. Air terminal units.
 - 2. Liners and adhesives.
 - 3. Sealants and gaskets.
 - 4. Seismic restraint devices.

- C. Shop Drawings: For air terminal units. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 2. Wiring Diagrams: For power, signal, and control wiring.
 - 3. Hangers and supports, including methods for duct and building attachment, bracing, and vibration isolation.

- D. Operation and Maintenance Data: For air terminal units 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. Instructions for resetting minimum and maximum air volumes.
 - 2. Instructions for adjusting software set points.

1.5 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

- B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."

PART 2 - PRODUCTS

2.1 PARALLEL FAN POWERED AIR TERMINAL UNITS

- A. Manufacturers:
 - 1. Anemostat Products.
 - 2. MetalAire, Inc.
 - 3. Nailor Industries, Inc.
 - 4. Price Industries.
 - 5. Titus.
 - 6. Trane.

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- B. Configuration: Volume-damper assembly and fan in parallel arrangement inside unit casing with control components inside a protective metal shroud.
- C. Casing: Single wall.
 - 1. Casing Lining: Adhesive attached, 1" thick fiberglass insulation complying with UL 181 erosion requirements, and having a maximum flame spread index of 25 and a maximum smoke developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
 - 2. Air Inlets: Round stub connections or S-slip and drive connections for duct attachment.
 - 3. Air Outlet: S-slip and drive connections.
 - 4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket and quarter-turn latches.
 - 5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- D. Motorized Volume Damper: Galvanized steel with flow sensing element, peripheral gasket, and bearings. Operating range shall be 90 degrees.
- E. Velocity Sensors: Multipoint array with velocity sensors in inlet duct connection.
- F. Motor: Refer to Division 23 Section "Common Motor Requirements for HVAC Equipment."
 - 1. Type: ECM.
 - 2. Design: Designed for speed control. Use with a SCR or other technology for fan speed adjustment. Provide means of speed control on the terminal unit by the terminal unit manufacturer.
- G. Fan:
 - 1. Type: Forward curved centrifugal.
 - 2. Isolation: Rubber in shear.
 - 3. Speed Control: Infinitely adjustable.
- H. Filters: Where return is ducted to unit, no filter at unit is required. Filter shall be provided at return filter grille.
- I. When indicated provide an Electric-Resistance Heating Coil: Nickel-chromium 80/20 heating wire, mounted in ceramic inserts in a galvanized steel housing; with primary automatic, and secondary manual, reset thermal cutouts. Terminate elements in stainless-steel, machine-staked terminals secured with stainless steel hardware.
 - 1. Control Stage(s)/Step(s): As indicated.
 - 2. Access door interlocked disconnect switch: Yes.
 - 3. High temperature limit: Downstream air temperature sensor with local connection to override discharge air temperature set point. Set point shall not exceed maximum discharge temperature set point. Discharge air temperature set point may not be used. If not used limit discharge air temperature to 180° F.

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4. Airflow switch for proof of airflow: Yes.
5. Fan interlock contacts: Yes.
6. Fuses in terminal box for overcurrent protection: Yes for coils more than 48 A.
7. Switches and relays: Yes
8. Contactor for each step of control: Yes

J. Factory mounted and wired components:

1. Electrical components and BAS unit controller mounted in control box with removable cover. Incorporate single point electrical connection to power source.
2. Control Transformer: 50 VA minimum factory mounted transformer for control voltage. Input voltage shall match the circuit provided. Coordinate output voltage with contractor performing work under Section "Building Automation System". Provide terminal strip in control box and field wiring of BAS unit controller to terminal strip. Wiring shall be as indicated.
3. Wiring Terminations: Fan, heat, and controls to terminal strip. Terminal lugs to match quantities, sizes, and materials of branch-circuit conductors and BAS requirements. Enclose terminal lugs in terminal box sized according to NFPA 70.
4. Disconnect Switch: Factory mounted fused.

K. Control Panel Enclosure: NEMA 250, Type 1, with access panel sealed from airflow and mounted on side of unit to enclose controller furnished under Section "Building Automation System".

L. Electronic Controls: Provide bidirectional damper, integral airflow measurement device, and transducer. Control devices shall be compatible with temperature controls specified in Section "Building Automation System" and shall comply with the following:

1. Install microprocessor based controller furnished under Section "Building Automation System"
2. Install damper actuator provided under this section.
3. Provide airflow transducer. Output shall be compatible with controller.

M. Control Sequence:

1. As indicated in Section "Sequences of Control."

2.2 SERIES FAN POWERED AIR TERMINAL UNITS

A. Manufacturers:

1. Anemostat Products.
2. MetalAire, Inc.
3. Nailor Industries, Inc.
4. Price Industries.
5. Titus.
6. Trane.

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- B. Configuration: Volume-damper assembly and fan in series arrangement inside unit casing with control components inside a protective metal shroud for installation above a ceiling.
- C. Casing: Single wall.
 - 1. Outer Casing: Galvanized sheet steel. Manufacturer's standard thickness.
 - 2. Lining: Adhesive attached, 1" thick fiberglass insulation complying with UL 181 erosion requirements, and having a maximum flame spread index of 25 and a maximum smoke developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
 - 3. Air Inlets: Round stub connections or S-slip and drive connections for duct attachment.
 - 4. Air Outlet: S-slip and drive connections.
 - 5. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket and quarter-turn latches.
 - 6. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
 - 7. Air Inlets: Round stub connections or S-slip and drive connections for duct attachment.
 - 8. Air Outlet: S-slip and drive connections.
 - 9. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket and quarter-turn latches.
- D. Fan:
 - 1. Type: Forward curved centrifugal.
 - 2. Isolation: Rubber in shear.
 - 3. Speed Control: Infinitely adjustable
- E. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- F. Volume Damper: Galvanized steel with flow-sensing ring and peripheral gasket and self-lubricating bearings.
- G. Velocity Sensors: Multipoint array with velocity sensors in inlet(s).
- H. Motor: Refer to Division 23 Section "Common Motor Requirements for HVAC Equipment."
 - 1. Type: ECM.
 - 2. Design: Designed for speed control. Use with a SCR or other technology for fan speed adjustment. Provide means of speed control on the terminal unit by the terminal unit manufacturer.

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- I. Filters: Where return is ducted to unit, no filter at unit is required. Filter shall be provided at return filter grille.

- J. When indicated, provide an Electric-Resistance Heating Coil: Nickel-chromium 80/20 heating wire, mounted in ceramic inserts in a galvanized steel housing; with primary automatic, and secondary manual, reset thermal cutouts. Terminate elements in stainless-steel, machine-staked terminals secured with stainless steel hardware.
 - 1. Control Stage(s)/Step(s): As indicated.
 - 2. Access door interlocked disconnect switch: Yes.
 - 3. High temperature limit: Downstream air temperature sensor with local connection to override discharge air temperature set point. Set point shall not exceed maximum discharge temperature set point. Discharge air temperature set point may not be used. If not used limit discharge air temperature to 180° F.
 - 4. Airflow switch for proof of airflow: Yes.
 - 5. Fan interlock contacts: Yes.
 - 6. Fuses in terminal box for overcurrent protection: Yes for coils more than 48 A.
 - 7. Switches and relays: Yes
 - 8. Contactor for each step of control: Yes

- K. Factory mounted and wired components:
 - 1. Electrical components mounted in control box with removable cover. Incorporate single point electrical connection to power source.
 - 2. Control Transformer: 50 VA minimum factory mounted transformer for control voltage. Input voltage shall match the circuit provided. Coordinate output voltage with contractor performing work under Section "Building Automation System". Provide terminal strip in control box and field wiring of BAS unit controller to terminal strip. Wiring shall be as indicated.
 - 3. Wiring Terminations: Fan and controls to terminal strip. Damper controls to terminal strip. Terminal lugs to match quantities, sizes, and materials of branch-circuit conductors and BAS requirements. Enclose terminal lugs in terminal box sized according to NFPA 70.
 - 4. Disconnect Switch: Factory mounted fused.

- L. Control Panel Enclosure: NEMA 250, Type 1, with access panel sealed from airflow and mounted on side of unit.

- M. Electronic Controls: Bidirectional damper operator and microprocessor based controller with integral airflow transducer. Control devices shall be compatible with temperature controls specified in Section "Building Automation System" and shall have the following features:
 - 1. Occupied and unoccupied operating mode.
 - 2. Remote reset of airflow set point.
 - 3. Adjusting and monitoring with portable terminal connected to BAS temperature sensor in space served.

4. Communication with BAS specified in Section "Building Automation System".

N. Control Sequence:

1. As indicated in Section "Sequences of Control"

2.3 SHUTOFF AIR TERMINAL UNITS

A. Manufacturers:

1. Anemostat Products.
2. MetalAire, Inc.
3. Nailor Industries, Inc.
4. Price Industries.
5. Titus.
6. Trane.

B. Configuration: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.

Casing: Single wall galvanized sheet steel.

1. Sheet Metal Thickness: Manufacturer's standard.
2. Casing Lining: Adhesive attached 1", fiberglass liner having a maximum flame spread index of 25 and a maximum smoke developed index of 50. Insulation shall comply with UL 181 erosion requirements.
3. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment. Provide flexible connector.
4. Air Outlet: S-slip and drive connections. Provide flexible connector.
5. Access: Removable panels with airtight gaskets for access to parts requiring service, adjustment, or maintenance.
6. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.

1. Damper Position: Normally open.

D. When indicated, provide an Electric-Resistance Heating Coil: Nickel-chromium 80/20 heating wire, mounted in ceramic inserts in a galvanized steel housing; with primary automatic, and secondary manual, reset thermal cutouts. Terminate elements in stainless-steel, machine-staked terminals secured with stainless steel hardware.

1. Control Stage(s)/Step(s): As indicated.
2. Access door interlocked disconnect switch: Yes.
3. High temperature limit: Downstream air temperature sensor with local connection to override discharge air temperature set point. Set point shall not exceed maximum

discharge temperature set point. Discharge air temperature set point may not be used. If not used limit discharge air temperature to 180° F.

4. Airflow switch for proof of airflow: Yes.
5. Fan interlock contacts: Yes.
6. Fuses in terminal box for overcurrent protection: Yes for coils more than 48 A.
7. Switches and relays: Yes
8. Contactor for each step of control: Yes

E. Factory mounted and wired components:

1. Electrical components mounted in control box with removable cover. Incorporate single point electrical connection to power source.
2. Control Transformer: 50 VA minimum factory mounted transformer for control voltage. Input voltage shall match the circuit provided. Coordinate output voltage with contractor performing work under Section "Building Automation System". Provide terminal strip in control box and field wiring of BAS unit controller to terminal strip. Wiring shall be as indicated.
3. Wiring Terminations: Fan and controls to terminal strip. Terminal lugs to match quantities, sizes, and materials of branch-circuit conductors and BAS requirements. Enclose terminal lugs in terminal box sized according to NFPA 70.
4. Disconnect Switch: Factory mounted fused.

F. Control Sequence:

1. As indicated in Section "Sequences of Control."

2.4 HANGERS AND SUPPORTS

A. Hanger Rods: Cadmium-plated steel rods, neoprene 1/8" thick washers and nuts.

1. Vibration isolation washers should be used on both sides of threaded rod attachment to box to prevent vibration transmission to structure.

B. 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.

C. Air Terminal Unit Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

D. Trapeze and Riser Supports: Steel shapes and plates for units with steel casings; aluminum for units with aluminum casings.

2.5 SOURCE QUALITY CONTROL

A. Label each air terminal unit with tag, nominal airflow, maximum and minimum factory-set airflows, coil type if coil is included, and ARI certification seal.

- B. For hydronic coils include hose kit and control valve shrink wrapped and labeled with terminal unit tag.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."
- B. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.

3.2 HANGER AND SUPPORT INSTALLATION

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "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 and for slabs equal to or more than 4" thick.
 - 4. Do not use powder actuated concrete fasteners for lightweight aggregate concretes and for slabs less than 4" thick.
- C. Hangers Exposed to View: Threaded rod and angle or channel supports.
- D. 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.

3.3 CONNECTIONS

- A. Install piping adjacent to air terminal unit to allow service and maintenance.
- B. Hot-Water Piping: In addition to requirements in Division 23 Section "Hydronic Piping," connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve and union or flange.
- C. Connect ducts to air terminal units according to division 23 duct specification sections for metal and flexible ducts.

- D. Make connections to air terminal units with flexible connectors complying with requirements in Division 23 Section "Air Duct Accessories."

3.4 IDENTIFICATION

- A. Label each air terminal unit with tag, nominal airflow, and maximum and minimum factory set airflows. Comply with requirements in Division 23 Section "Identification for HVAC Piping and Equipment" for equipment labels and warning signs/labels.

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.
- B. Tests and Inspections:
 - 1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
 - 2. Leak Test: After installation, fill water coils 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 motor rotation and unit operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Air terminal unit will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

3.6 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
 - 2. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
 - 3. Verify that controls and control enclosure are accessible.
 - 4. Verify that control connections are complete.
 - 5. Verify that nameplate and identification tag are visible.
 - 6. Verify that controls respond to inputs as specified.

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3.7 DEMONSTRATION

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

END OF SECTION 233600

SECTION 233713 - DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Provisions of the Contract and of the Contract Documents apply to this Section.

1.2 SUBMITTALS

- A. Product Data: For each type of product indicated, include the following:
1. Data Sheet: Indicate materials of construction, finish, mounting details, and performance data including throw, 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.

PART 2 - PRODUCTS

2.1 DIFFUSERS, GRILLES, AND REGISTERS

A. Manufacturers:

1. Anemostat.
2. Carnes.
3. Krueger.
4. MetalAire, Inc.
5. Nailor Industries.
6. Price Industries.
7. Titus.
8. Tuttle & Bailey.

B. General:

1. All trim pieces shall be mechanically fastened. Friction fit trim rings/frames shall not be provided or shall be mechanically fastened in the field. Fasteners shall not be visible.
2. Finish:
 - a. Powder-coated or baked enamel, white, unless noted otherwise.
 - b. For sidewall-mounted inlets and outlets, provide finish suitable for field painting where indicated (color shall be selected by Architect) or provide anodized clear finish where indicated.
 - c. Finish for Exposed Ductwork: Where ductwork is exposed, inlets and outlets mounted in exposed ductwork shall be factory primed for field painting.

3. Filter Grille Mounting Frame: Shall accept a 2" deep MERV 8 (30%) pleated media filter. Refer to Section "Particulate Air Filtration" for filter requirements. Provide two sets of filters for each filter grille.
4. Mounting: As indicated in schedule or match condition indicated.

C. Linear Slot Diffuser Plenums

1. Linear slot diffuser plenums shall be fully insulated. Provide one of the following:
 - a. Factory-installed, internal fiberglass insulation on sides and end caps.
 - b. Factory-installed, external aluminum foil-backed insulation.
 - c. Field-installed external insulation on plenums not factory-insulated. Refer to Section 230700 HVAC Insulation.

D. Ceiling Diffusers

1. Ceiling diffuser backpans shall be externally insulated. Provide one of the following:
 - a. Factory-installed with foil/scrim vapor barrier insulation with an R-value of six.
 - b. Field-installed external insulation on backpans not factory-insulated. Refer to Section 230700 HVAC Insulation.

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 EXAMINATION

- A. Examine areas where diffusers, registers, and grilles are to be installed for installation tolerances and other conditions affecting performance.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install diffusers, registers, and grilles level and plumb.
- B. Install diffusers, registers, and grilles flush with ceiling unless otherwise indicated.
- C. 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. Install in locations indicated as much as practical. For units installed in lay-in ceiling panels, center units

in both directions in panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

- D. Linear Slot Diffuser Installation: Adjust each slot diffuser so half the slots throw horizontally along the ceiling in each direction unless indicated otherwise. For linear slot diffusers above windows at building perimeter, one half of the total slots at each diffuser shall be adjusted to throw air vertically downward to wash window, and the other half of the slots shall be adjusted to throw air horizontally across ceiling unless indicated otherwise.
- E. Diffusers, registers and grilles shall be supported independently of the ceiling system and shall not be supported from conduit, piping or unrelated ductwork.
- F. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance.

3.3 ADJUSTING

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

END OF SECTION 233713

SECTION 233723 - HVAC GRAVITY 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 PERFORMANCE REQUIREMENTS

- A. Structural Performance: Ventilators shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated without permanent deformation of ventilator components, noise or metal fatigue caused by ventilator blade rattle or flutter, or permanent damage to fasteners and anchors. Wind pressures shall be considered to act normal to the face of the building.
 - 1. Wind Loads: Determine loads based on pressures as indicated on Drawings.
- B. Water Entrainment: Limit water penetration through unit to comply with ASHRAE 62.1-2004.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated. For roof hoods and ventilators specified to bear AMCA seal, include printed catalog pages showing specified models with appropriate AMCA Certified Ratings Seals.
- B. Shop Drawings: For gravity ventilators. Include plans, elevations, sections, details, ventilator attachments to curbs, and curb attachments to roof structure.
 - 1. Show weep paths, gaskets, flashing, sealant, and other means of preventing water intrusion.

1.4 COORDINATION

- A. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

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. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 MATERIALS

- A. Aluminum Extrusions: ASTM B 221, Alloy 6063-T5 or T-52.
- B. Aluminum Sheet: ASTM B 209, Alloy 3003 or 5005 with temper as required for forming or as otherwise recommended by metal producer for required finish.
- C. Galvanized-Steel Sheet: ASTM A 653/A 653M, G90 zinc coating, mill phosphatized.
- D. Fasteners: Same basic metal and alloy as fastened metal or 300 Series stainless steel, unless otherwise indicated. Do not use metals that are incompatible with joined materials.
 - 1. Use types and sizes to suit unit installation conditions.
 - 2. Use hex-head or Phillips pan-head screws for exposed fasteners, unless otherwise indicated.
- E. Post-Installed Fasteners for Concrete and Masonry: Torque-controlled expansion anchors, made from stainless-steel components, with capability to sustain, without failure, a load equal to 4 times the loads imposed, for concrete, or 6 times the load imposed, for masonry, as determined by testing per ASTM E 488, conducted by a qualified independent testing agency.
- F. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D 1187.

2.3 FABRICATION, GENERAL

- A. Factory or shop fabricate gravity ventilators to minimize field splicing and assembly. Disassemble units to the minimum extent as necessary for shipping and handling. Clearly mark units for reassembly and coordinated installation.
- B. Fabricate frames, including integral bases, to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances, adjoining material tolerances, and perimeter sealant joints.

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- C. Fabricate units with closely fitted joints and exposed connections accurately located and secured.
- D. Fabricate supports, anchorages, and accessories required for complete assembly.
- E. Perform shop welding by AWS-certified procedures and personnel.

2.4 ROOF HOODS

- A. Manufacturers:
 - 1. Acme Engineering & Mfg. Corporation.
 - 2. Greenheck Fan Corporation.
 - 3. Loren Cook Company.
- B. Factory or shop fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figures 5-6 and 5-7.
- C. Materials: Aluminum, minimum 0.064-inch- thick base and 0.040-inch- thick hood; suitably reinforced.
- D. Roof Curbs: Mitered and welded corners; 1-1/2-inch- thick, rigid fiberglass insulation adhered to inside walls; integral damper tray; and 1-1/2-inch wood nailer. Size as required to fit roof opening and ventilator base.
 - 1. Material: Material shall match that of the hood.
 - 2. Configuration: Self-flashing without a cant strip, with mounting flange.
 - 3. Overall Height: 16 inches.
 - 4. Pitch Mounting: Manufacture curb for roof slope.
- E. Bird Screening: Aluminum, 1/2-inch- square mesh, 0.063-inch wire.
- F. Damper: Gravity backdraft type, spark resistant.
- G. Finish:
 - 1. Surface Preparation: Clean surfaces of dirt, grease, and other contaminants. Clean welds, mechanical connections, and abraded areas and repair galvanizing according to ASTM A 780. Apply a conversion coating suited to the organic coating to be applied over it.
 - 2. Baked-Enamel Finish: Immediately after cleaning and pretreating, apply manufacturer's standard finish consisting of prime coat and thermosetting topcoat, with a minimum dry film thickness of 1 mil for topcoat and an overall minimum dry film thickness of 2 mils.
 - a. Color and Gloss: Match selected roof color.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install gravity ventilators level, plumb, and at indicated alignment with adjacent work.
- B. Install gravity ventilators with clearances for service and maintenance.
- C. Install perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.
- D. Install concealed gaskets, flashings, joint fillers, and insulation as installation progresses. Comply with Division 07 Section "Joint Sealants" for sealants applied during installation.
- E. Label gravity ventilators according to requirements specified in Division 23 Section "Identification for HVAC Piping and Equipment."
- F. Protect galvanized and nonferrous-metal surfaces from corrosion or galvanic action by applying a heavy coating of bituminous paint on surfaces that will be in contact with concrete, masonry, or dissimilar metals.
- G. Repair finishes damaged by cutting, welding, soldering, and grinding. Restore finishes so no evidence remains of corrective work. Return items that cannot be refinished in the field to the factory, make required alterations, and refinish entire unit or provide new units.

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.

END OF SECTION 233723

SECTION 234100 - PARTICULATE AIR FILTRATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Provisions of the Contract and of the Contract Documents apply to this Section.

1.2 DEFINITIONS

- A. Construction Filter: A filter maintained during construction to protect ductwork from construction dust, dirt, and debris. Construction filters shall be removed temporarily during balancing and permanently after the building is occupied.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated include dimensions, required operating clearances, required access clearances, and weights.
- B. Operating Characteristics: For each type of product indicated provide rated flow capacity, initial and final pressure drop at rated flow capacity.
- C. Efficiency: For each type of product indicated efficiency/MERV rating and test method.
- D. Fire Classification: For each type of product indicated provide the fire classification.
- E. Specialties and Accessories: For each type of product indicated provide furnished specialties and accessories.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For each type of filter and rack to include in emergency, operation, and maintenance manuals.
- B. Replace all permanent filters with new filters of types specified.

1.5 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. ASHRAE Compliance:

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1. Comply with applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality"; Section 5 - "Systems and Equipment"; and Section 7 - "Construction and Startup."
2. Comply with ASHRAE 52.1 for arresstance and ASHRAE 52.2 for MERV for methods of testing and rating air-filter units.

C. Comply with NFPA 90A and NFPA 90B.

1.6 COORDINATION

- A. Coordinate sizes and locations:
1. Within air handling units.
 2. On open return ducts during construction.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers:
1. Air Filters, and Filter-Holding Systems:
 - a. 3M.
 - b. Airguard.
 - c. American Air Filter Company, Inc. Flanders.
 - d. Camfil USA.
 - e. Columbus Industries, Inc.
 - f. Koch Filter Corp.

2.2 GENERAL FILTERS

- A. For return filter grilles, general filtration, and construction filters provide the following:
1. Media: Cotton and synthetic pleated with an average efficiency of 25-30% and an average arresstance of 90-92% in accordance with ASHRAE test standard 52.1-1992.
 2. Thickness: Unless otherwise indicated thickness shall be 2".
 3. Media Support Grid: Welded wire on 1" centers with 96% free area bonded to the media.
 4. Filter Frame: High wet strength cardboard with diagonal support members bonded to the media on the entering side and exiting side of each pleat.
 5. Holding Frame: Galvanized steel with metal grid on outlet side, polyurethane gaskets, and spring fasteners.
 6. Farr 30/30 or equal.

2.3 PRE-FILTERS

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- A. Where pre-filters are indicated and for construction filters provide the following:
1. Media: Cotton and synthetic pleated with an average efficiency of 25-30% and an average arrestance of 90-92% in accordance with ASHRAE test standard 52.1-1992.
 2. Thickness: Unless otherwise indicated thickness shall be 2".
 3. Media Support Grid: Welded wire on 1" centers with 96% free area bonded to the media.
 4. Filter Frame: High wet strength cardboard with diagonal support members bonded to the media on the entering side and exiting side of each pleat.
 5. Holding Frame: Galvanized steel with metal grid on outlet side, polyurethane gaskets, and spring fasteners.
 6. Farr 30/30 or equal.

2.4 FINAL FILTERS (CARTRIDGE TYPE)

- A. Where cartridge type final filters are indicated on the drawings provide the following:
1. Media: High density microfine glass fibers, laminated to a reinforcing backing to form a lofted filter blanket.
 2. Minimum Efficiency Reporting Value: MERV 13 in accordance with ASHRAE 52.2.
 3. Thickness: Unless otherwise indicated thickness shall be 12" for RTU and 2 or 4" for DOAU depending on equipment options.
 4. Media Support Grid: Welded wire on 1" centers with 96% free area bonded to the media.
 5. Contour Stabilizers: Aluminized zinc finished steel strips permanently installed on the entering and leaving side of the filter. Filter shall withstand 10" of static pressure drop without noticeable distortion.
 6. Filter Frame: Aluminized zinc finished steel with filter pack mechanically and chemically bonded to eliminate air bypass. Provide aluminized zinc finished steel diagonal supports
 7. Holding Frame: 16 Gauge galvanized steel with polyurethane gaskets, and positive sealing fasteners.
 8. Farr Riga-Flo 100 or equal.

2.5 INSTALLATION

- A. Position each filter with clearance for normal service and maintenance.
- B. Install filters to prevent passage of unfiltered air.
- C. Do not operate fan system until filters are in place. During construction, all ductwork must be protected from dirt and debris. Remove filters used during construction and testing. Replace all filters in units with new filters of types specified.
- D. Unit operation during construction:
1. Install minimum MERV 8 construction filters to protect all return ductwork from dirt and debris. Supply fan shall operate at all times.
- E. Unit not operating during construction:

1. Install plastic sheet material over all supply and return openings to protect all ductwork from dirt and debris.
2. Fans shall be off.

F. Construction filter installation: Adhere all edges of filter with metal foil peel-n-stick tape having an acrylic adhesive.

2.6 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
 1. Check for leakage of unfiltered air while system is operating.
- B. Air filter and installation will be considered defective if they do not pass.
- C. Prepare a report for each filter.

2.7 TESTING AND BALANCING

- A. Immediately prior to testing and balancing, install new filters of the same type that shall be permanently installed.

2.8 CLEANING

- A. After construction ends and prior to occupancy, and with all interior finishes installed, clean unit filter housings and install new filters.

END OF SECTION 234100

SECTION 237313 - ROOFTOP UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The Drawings and general provisions of the Contract Documents apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Variable-air volume rooftop units.

1.3 SUBMITTALS

- A. Pre-Submittal Meeting: A representative of the manufacturer producing equipment provided under this Section of the specifications shall attend a meeting for the purpose of coordinating with the contractor performing work under section "Building Automation System." The Contractor shall arrange the meeting. Submittals shall be essentially complete, and a pre-submittal shall be provided one week prior to the meeting.
- B. Product Data: For each rooftop unit, include manufacturer's technical data for each model indicated, including rated capacities, dimensions, required clearances, characteristics, furnished specialties, fan performance curves, coil capacities, filters, and accessories.
- C. Field quality-control reports.
- D. Operation and Maintenance Data: For rooftop units to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of rooftop units and components.
- C. ARI Certification: Rooftop units and their components shall be factory tested according to ARI 430, "Central-Station Air-Handling Units," and shall be listed and labeled by ARI.
- D. Comply with NFPA 70.

1.5 COORDINATION

- A. Coordinate sizes and locations of structural-steel support members, if any, with actual equipment provided.
- B. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

1.6 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. Filters: One set(s) for each rooftop unit.
 - 2. Fan Belts: One set(s) for each rooftop unit fan.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Carrier
 - 2. Daikin Applied.
 - 3. Trane.

2.2 PACKAGED ROOFTOP UNITS (RTU-1)

- A. Description:
 - 1. Unit shall be factory-assembled and -tested, internally wired, fully charged with refrigerant, and run tested prior to shipment. Run test report shall be supplied with the unit in the service compartment's literature pocket.
 - 2. Unit shall have decals and tags to indicate lifting and rigging, service areas and caution areas for safety and to assist service personnel.
 - 3. Unit components shall be labeled, including refrigeration system components and electrical and controls components.
 - 4. Estimated sound power levels (dB) shall be shown on the unit ratings sheet.
 - 5. Laminated color-coded wiring diagram shall match factory installed wiring and shall be affixed to the interior of the control compartment's hinged access door.
 - 6. Unit nameplate shall be provided in two locations on the unit, affixed to the exterior of the unit and affixed to the interior of the control compartment's hinged access door.
 - 7. These units operate at variable speed and serve VAV air terminal units.
- B. Casing:

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1. Exterior panels shall be zinc coated galvanized steel, phosphatized, and painted with a finish durable enough to withstand a minimum of 672 hours consecutive salt spray application in accordance with standard ASTM B117.
 2. Screws shall be coated with zinc-plus-zinc chromate. Heavy gauge steel hinged access panels with tiebacks to secure door in open position shall provide access to filters and heating sections.
 3. Refrigeration components, supply air fan and compressor shall be accessible through removable panels.
 4. Unit control panel, filter section, and gas heating section shall be accessible through hinged access panels. Double wall construction hinged access doors shall provide access to filters, return/exhaust air, heating, and supply fan section. All access doors and panels shall have neoprene gaskets.
 5. Interior surfaces or exterior casing members shall have 1/2" fiberglass insulation. Unit base shall be watertight with heavy gauge formed load bearing members, formed recess and curb overhang. Unit lifting lugs shall accept chains or cables for rigging. Lifting lugs shall also serve as unit tiedown points.
 6. The sheet metal liners shall provide a mechanical fastener for insulation and prevent the possibility of loose insulation fibers from entering the airstream. All interior airstream insulation shall be lined, with the exception of the vertical supports, which shall have foil faced insulation.
- C. Condenser:
1. Condenser coils shall have all aluminum microchannel coils. All coils shall be leak tested at the factory to ensure pressure integrity. The condenser coil shall be pressure tested to 650 psig. Subcooling circuit(s) shall be provided.
 2. All condenser fans shall be vertical discharge, direct drive fans, statically balanced, with aluminum blades and zinc plated steel hubs. Condenser fan motors shall be three-phase motors with permanently lubricated ball bearings, built-in current and thermal overload protection and weathertight slingers over motor bearings.
- D. Evaporator:
1. Internally enhanced copper tubing of 3/8" or 1/2" O.D. shall be mechanically bonded to heavy duty aluminum fins of configured design. All coils shall be equipped with thermal expansion valves and factory pressure and leak tested.
 2. Provide condensate pan overflow sensor that shuts down unit if condensate pan fills above drain outlet elevation.
- E. Compressors:
1. Scroll compressor shall be industrial grade, direct drive 3600 RPM maximum speed scroll type. The motor shall be suction gas-cooled hermetic design. Compressor shall have centrifugal oil pump with dirt separator, oil sight glass, and oil charging valve. Compressor shall also be provided with thermostatic motor winding temperature control to protect against excessive motor temperatures resulting from over-/under-voltage or loss of charge, high and low pressure cutouts, and reset relay.
- F. Phase Monitor:
1. Shall protect 3-phase equipment from phase loss, phase reversal, and low voltage. Any fault condition shall produce a failure indicator LED and send the unit into an emergency stop condition.

G. Gas-Fired Heating:

1. All gas-fired units shall be completely assembled and have a wired gas fired heating system integral within unit. Units shall be cULus approved specifically for outdoor applications downstream from refrigerant cooling coils.
2. All gas piping shall be threaded connection with a pipe cap provided. Gas supply connection shall be provided through the side or bottom of unit.
3. Heat Exchanger shall be tubular two pass design with stainless steel primary and secondary surfaces. Gasketed cleanout plate shall be provided for cleaning of tubes/turbulators. Heat exchanger shall be factory pressure and leak tested.
4. Burner shall be a stainless steel industrial type with an air proving switch to prevent burner operation if the burner is open for maintenance or inspection. Ceramic cone shall be provided to shape the flame to prevent impingement on sides of heat exchanger drum. Burner assembly shall house ignition and monitoring electrode.
5. Combustion blower shall be centrifugal type fan. Fan motor shall have built-in thermal overload protection.
6. Gas safety controls shall include electronic flame safety controls to require proving of combustion air prior to ignition sequence which shall include a 60 second pre-purge cycle. Pilot ignition shall be provided. Continuous electronic flame supervision shall be provided. Gas heaters shall be made from grades of stainless steel suitable for condensing situations. The heater shall have a turn down ratio of at least 14 to 1.

H. Supply Fan:

1. Supply fan motors shall be either open drip-proof or enclosed fan cooled. All supply fans shall be dynamically balanced in factory. Supply fan shall be test run in unit and shall reach rated rpm. Comply with the requirements of Section "Motors for HVAC Equipment."
2. Direct-Drive Plenum Supply Fan: Supply fan shall be two single width, single inlet plenum fan. Fan blades shall be aluminum backward-inclined airfoil. Plenum fans shall be direct-driven. Entire assembly shall be completely isolated from unit and fan board by 2" deflection spring isolation.

I. Variable Frequency Drive:

1. Provide factory-installed and tested variable frequency drive[s] (VFD) to provide motor speed modulation. The VFD shall receive a 0-10VDC speed signal from the unit controller. The drive will respond to the signal by accelerating or decelerating to maintain the controlling set point (duct static). VFD shall also include the following features:
 - a. Designed, constructed, and tested in accordance with NEMA ICS, NFPA, and IEC standards and housed in a plastic IP20 enclosure.
 - b. DC link reactors on both the positive and negative rails of the DC bus equal to 3% impedance to minimize power line harmonics.
 - c. Full rated output current continuously - 110% of rated current for 60 seconds and 160% of rated current for up to 0.5 second while starting.
 - d. Isolation between the drive's power circuitry and control circuitry.
 - e. Audible noise reduction through automatic adjustment of the carrier frequency and frequency avoidance.
 - f. Rated at 40C with a standard operating range of 14 to 124F ambient temperatures and 0 to 95% relative humidity.
 - g. Self-diagnostics and motor protections such as: cULus listed overload, phase loss, and internal thermal overload.

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- h. Off/Stop and Auto/Start selector switches to start and stop the AC Drive and determine the speed reference.
 - 1) On units with bypass, an AC Drive/Off/Bypass hand selector switch shall be provided in the unit control box.
 - 2) In DRIVE mode, speed reference shall be provided by a 0-10 VDC analog input.
 - i. A keypad interface which shall be programmable by language and feature multiple lines.
 - j. Controlled and/or accessible points such as AC Drive Start/Stop, speed reference, and fault diagnostics.
 - k. Meter points such as motor power in HP, motor power in kW, motor kW-hr, motor current, motor voltage, hours run, DC link voltage, thermal load on motor, thermal load on AC Drive and heatsink temperature.
 - l. Troubleshooting features such as:
 - 1) AC drive memory storage of the last 10 faults and related operational data
 - 2) Four simultaneous displays: frequency or speed, run time, output amps, and output power.
 - 3) Keypad which shall display: Reference signal value, output frequency in Hz or percent, output amps, motor HP, motor kW.
 - 4) Field readable BACnet points to allow for communication of status, setpoints and diagnostics to the BAS.
 - 2. Bypass control shall provide full nominal airflow in the event of drive failure.
- J. Spring Isolators: Supply and exhaust fan assemblies shall be isolated with two-inch nominal deflection to reduce transmission of vibrations.
- K. Exhaust Fan:
- 1. Provide 100% modulating return fan and 100% modulating return with building pressurization control.
 - 2. A single width plenum fan with airfoil blade shall be mounted on a shaft with fixed sheave drive. The fan shall be dynamically balanced for the operating envelope and tested in factory before being installed in unit. The plenum fan shall be test run as part of unit final run test. Fan operating envelope rpm shall be below first critical speed.
 - 3. Fan shaft shall be mounted on two grease lubricated ball or roller bearings designed for 200,000- hour average life. Extended grease lines shall be provided to allow greasing of bearings from section base rail. Fan motor and assembly shall be mounted on common base.
 - 4. The entire assembly shall be completely isolated from unit with 2-inch spring isolators. Provide with all the necessary controls to control/maintain building space pressure through a VAV rooftop. The variable frequency drive (VFD) shall modulate the speed of the return fan motor in response to return plenum pressure. The 100 percent modulating relief damper shall be modulated in response to building pressure. A differential pressure control system shall use a differential pressure transducer to compare indoor building pressure to outdoor ambient atmospheric pressure. The control system shall modulate the dampers to control the building pressure to within the adjustable, specified dead band that shall be adjustable at the human interface panel. The return fan shall modulate in response to return plenum static pressure. VFD bypass control provides full nominal airflow in the event of drive failure.
- L. Economizer:

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1. Operated through the primary temperature controls to automatically utilize OA for free cooling. Automatically modulated return and OA dampers shall maintain proper temperature in the conditioned space.
2. Economizer shall be equipped with an automatic lockout when the outdoor high ambient temperature is too high for proper cooling.
3. Minimum position control shall be standard and adjustable at the Human Interface Panel or with a remote potentiometer or through the building management system.
4. A spring return motor shall ensure closure of OA dampers during unit shutdown or power interruption.
5. Mechanical cooling shall be available to aid the economizer mode at any ambient.
6. Low leak economizer dampers shall be standard with a leakage rate of 2.5 percent of nominal airflow at 1" wg. static pressure. Dampers shall be provided with chlorinated polyvinyl chloride gasketing added to the damper blades and rolled stainless steel jamb seals to the sides of the damper assembly.
7. Dampers shall have a leakage rate of 1% at 1.0 in WC pressure differential
8. Reference Enthalpy Control: An outdoor enthalpy sensor shall be provided to compare total heat content of the outdoor air to a locally adjustable setpoint. The setpoint (initially 28 BTU/lb.) shall be programmed at the control interface to determine if outdoor enthalpy condition is suitable for economizer operation.

M. Outside Air Measurement:

1. Provide Traq damper or approved alternative to measure outside airflow. Ventilation Control Module (VCM). The VCM shall be linked to the unit controller to control the minimum fresh air entering the unit. Using a velocity pressure sensing ring, the VCM shall monitor and control the quantity of fresh air entering the unit. This allows it to control to the minimum outside airflow setpoint.

N. Filters:

1. Provide 12" deep cartridge filters mounted in a galvanized steel frame. Filters shall be MERV 13 Class 1 listed by Underwriters Laboratories and have a 90-95% dust spot efficiency per ASHRAE 52-76.
2. Provide 2" MERV 8 prefilters.

O. Unit Controller:

1. DDC microprocessor controls shall be provided to control all unit functions. The control system shall be suitable to control VAV applications. The controls shall be factory-installed and mounted in the main control panel. All factory-installed controls shall be fully commissioned (run tested) at the factory.
2. Unit shall have integral outside air flow measuring and downstream static pressure measuring. A building pressure sensor will be provided with unit and field wired.
3. The unit shall have a Human Interface Panel with a 16 key keypad, a 2 line X 40 character clear English display as standard to provide the operator with full adjustment and display of control data functions. The unit controls shall be used as a stand-alone controller, or as part of a building management system involving multiple units.
4. The unit shall be equipped with a complete microprocessor control system. This system shall consist of temperature and pressure (thermistor and transducer) sensors, printed circuit boards (modules), and a unit mounted Human Interface Panel. Modules (boards) shall be individually replaceable. All microprocessors, boards and sensors shall be factory mounted, wired, and tested. The microprocessor boards shall be stand-alone DDC controls not dependent on communications with an on-site PC or a Building Management

Network. The microprocessors shall be equipped with on-board diagnostics, indicating that all hardware, software, and interconnecting wiring are in proper operating condition. The modules (boards) shall be protected to prevent RFI and voltage transients from affecting the board's circuits. All field wiring shall be terminated at a terminal strip.

5. The microprocessor's memory shall be non-volatile EEPROM type requiring no battery or capacitive backup, while maintaining all data.
6. The Human Interface Panel's keypad display character format shall be 40 characters x 2 lines. The display shall be LCD. The display format shall be in clear English.
7. Provide a BACnet communication interface to control and monitor the rooftop by the BAS using BACnet protocol.

P. Electrical:

1. Unit Interrupt Rating (Standard Short Circuit Current Rating-SCCR): A 5,000 amp rating shall be applied to the unit enclosure using a non-fused circuit breaker for disconnect switch purposes. Fan motors, compressors, and electric heat circuits shall be provided with protective devices that will provide the unit rated level of fault protection. The unit shall be marked with approved cULus markings and shall adhere to cULus regulations.
2. Non-fused disconnect with external handle: Provide disconnect for unit power.

Q. Roof Curb:

1. Provide curb with vibration isolation, refer to 230548 Vibration Control for HVAC for additional requirements.
2. Provide aluminum counterflashing covering vibration curb gasket to protect from direct sun and water penetration.
3. wiring.

R. Warranty:

1. Compressor: 5 years.
2. Heat Exchanger: 15 years.
3. Complete Unit: 1 year.

S. Accessories:

1. Phase monitor: provide monitor to prevent damage in out-of-phase condition.
2. Single point power with factory-installed, non-fused disconnect switch.
3. Condensate overflow switch.
4. Hail Guards: Protects the condensing unit from damage due to extreme weather conditions such as hail and flying debris.

2.3 SOURCE QUALITY CONTROL

- A. Fan Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Fans shall bear AMCA-certified sound ratings seal.
- B. Fan Performance Rating: Factory test fan performance for airflow, pressure, power, air density, rotation speed, and efficiency. Rate performance according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating."

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine casing insulation materials and filter media before rooftop unit installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.
- B. Examine roughing-in for condensate drainage piping systems and electrical services to verify actual locations of connections before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Equipment Mounting: Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration Controls for HVAC Piping and Equipment."
- B. Arrange installation of units to provide access space around rooftop units for service and maintenance.
- C. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with new, clean filters.

3.3 CONNECTIONS

- A. Comply with requirements for piping specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to rooftop unit to allow service and maintenance.
- C. Connect condensate drain pans and extend to nearest roof drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction. Comply with requirements in Division 23 Section "Hydronic Piping."
- D. Connect duct to rooftop units with flexible connections. Comply with requirements in Division 23 Section "Air Duct Accessories."

3.4 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- B. Tests and Inspections:

1. Fan 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.
- C. Rooftop unit or components will be considered defective if unit or components do not pass tests and inspections.
- D. Prepare test and inspection reports.

3.5 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
1. Complete installation and startup checks according to manufacturer's written instructions.
 2. Verify that shipping, blocking, and bracing are removed.
 3. 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, controllers, and switches.
 4. Verify proper motor rotation direction, free fan wheel rotation, and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
 5. Verify that bearings, pulleys, belts, and other moving parts are lubricated with factory-recommended lubricants.
 6. Verify that outdoor- and return-air mixing dampers open and close and maintain minimum outdoor-air setting.
 7. Comb coil fins for parallel orientation.
 8. Verify that proper thermal-overload protection is installed for electric coils.
 9. Install new, clean filters.
- B. Starting procedures for rooftop units include the following:
1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm.

3.6 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Comply with requirements in Section "Testing, Adjusting, and Balancing for HVAC" for rooftop system testing, adjusting, and balancing.

3.7 CLEANING

- A. After startup service, clean rooftop 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.

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- B. After completing system installation and testing, adjusting, and balancing rooftop unit and air-distribution systems, clean filter housings and install new, clean filters.

3.8 DEMONSTRATION

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

END OF SECTION 237313

SECTION 237433 – DEDICATED OUTDOOR AIR UNITS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes packaged, outdoor, central-station air-handling units with the following components and accessories:
 - 1. Direct-expansion cooling.
 - 2. Electric Heat
 - 3. Enthalpy wheel.
 - 4. Supply and exhaust fans.
 - 5. Filters.

1.2 SUBMITTALS

- A. Product Data: Include manufacturer's technical data for each OAU, including rated capacities, dimensions, required clearances, characteristics, furnished specialties, and accessories.
- 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.
- C. Field quality-control test reports.
- D. Warranty.
- E. Operation and maintenance data.

1.3 QUALITY ASSURANCE

- A. Compliance:
 - 1. Packaged air-cooled condenser units shall be certified in accordance with ANSI/AHRI Standard 340/360 *Performance Rating of Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment*.
 - 2. Comply with ARI 270 for testing and rating sound performance for OAUs.
 - 3. Comply with ASHRAE 15 for refrigerant system safety.
 - 4. Comply with applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
 - 5. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

6. NFPA Compliance: Comply with NFPA 90A and NFPA 90B.
7. Units shall be safety certified by ETL and ETL US listed.

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.

1.4 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to replace components of OAU's that fail in materials or workmanship within specified warranty period.
1. Warranty Period for Compressors: Five years.
 2. Warranty Period for Remainder of Unit: Manufacturer's standard, but not less than one year.

PART 2 - PRODUCTS

2.1 PACKAGED OUTDOOR AIR UNITS

A. Manufacturers:

1. Daikin Applied, Inc.
2. Greenheck Fan Corporation.
3. Trane
4. Valent.

B. Description:

1. Packaged air-handling unit shall include compressors, evaporator coil, filters, supply fan, dampers, air-cooled condenser, condenser fans, hot gas reheat coil, heater, relief fan, energy recovery wheel, and unit controls.
2. Unit shall be factory assembled and tested including leak testing of the DX coils, pressure testing of the refrigeration circuit, and run testing of the completed unit. Run test report shall be supplied with the unit in the service compartment's literature pocket.
3. Unit shall have decals and tags to indicate lifting and rigging, service areas and caution areas for safety and to assist service personnel.
4. Unit components shall be labeled, including refrigeration system components and electrical and controls components.
5. Estimated sound power levels (dB) shall be shown on the unit ratings sheet.
6. Installation, Operation, and Maintenance manual shall be supplied within the unit.
7. Laminated color-coded wiring diagram shall match factory installed wiring and shall be affixed to the interior of the control compartment's hinged access door.
8. Unit nameplate shall be provided in two locations on the unit, affixed to the exterior of the unit and affixed to the interior of the control compartment's hinged access door.

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C. CONSTRUCTION

1. Materials: Formed, double wall insulated metal cabinet.
2. Outside casing: 18 gauge, galvanized (G90) steel meeting ASTM A653 for components that do not receive a painted finish. Pre-painted components as supplied by the factory shall have polyester urethane paint on 18-gauge G60 galvaneal steel. Unit's exterior shall be supplied from the manufacturer using G60 galvaneal steel with pre-painted material. Paint shall meet salt spray test per ASTM-B117 and evaluated using ASTM-D714 and ASTM-D610 showing no observable signs of rust or blistering until reaching 2,500 hours.
3. Internal assemblies: 24 gauge, galvanized (G90) steel except for motor supports which shall be minimum 14 gauge galvanized (G90) steel.
4. Cabinet Insulation: Comply with NFPA 90A and NFPA 90B and erosion requirements of UL 181.
5. Materials: Rigid urethane foam
6. Thickness: 2 inches
7. Meets UL94HF-1 flame requirements.
8. Location and application: Full coverage of entire cabinet exterior to include walls, roof of unit, unit base, and doors.
9. Access panels / doors: Unit shall be equipped with insulated, hinged doors or removable access panels to provide easy access to all major components. Doors and access panels shall be fabricated of 18-gauge galvanized G90 steel or painted galvanized steel.
10. Roof of the air tunnel shall be sloped to provide complete drainage. Cabinet shall have rain break overhangs above access doors.
11. Access to filters, dampers, cooling coils, reheat coil, heaters, exhaust fans, energy recovery wheels, compressors, and electrical and controls components shall be through hinged access doors with quarter turn, lockable handles.
12. Unit shall include double-sloped 304 stainless steel drain pans.
13. Unit shall be provided with base discharge and return air openings. All openings through the base pan of the unit shall have upturned flanges of at least 1/2 inch in height around the opening.
14. Unit shall include lifting lugs on the top of the unit.

D. SUPPLY AND EXHAUST FANS

1. Supply Air blower assembly: Blower assembly shall consist of an electric motor and direct-drive fans. Assembly shall be mounted on heavy gauge galvanized steel rails and further mounted on 1.125-inch-thick neoprene vibration isolators. Blower motors shall be capable of continuous speed modulation and controlled by a VFD.
2. Exhaust Air blower assemblies: Blower assembly shall consist of an electric motor and a direct-drive fan. Assembly shall be mounted on heavy gauge galvanized steel rails and further mounted on 1.125-inch-thick neoprene vibration isolators. Blower motor shall be capable of continuous speed modulation and controlled by a VFD.
3. Blower section construction, Supply Air: direct drive motor and blower shall be assembled on a 14-gauge galvanized steel platform and shall be equipped with 1.125-inch-thick neoprene vibration isolation devices.
4. Blower assemblies: Shall be statically and dynamically balanced and designed for continuous operation at maximum rated fan speed and horsepower.
5. Fan: Direct drive, airfoil plenum fan with steel wheels statically and dynamically balanced and AMCA certified for air and sound performance.
6. Blower section motor source quality control: Blower performance shall be factory tested for flow rate, pressure, power, air density, rotation speed and efficiency. Ratings are to be

established in accordance with AMCA 210, "Laboratory Methods of Testing Fans for Rating".

7. Variable frequency drives shall be factory wired and mounted in the unit. Fan motors shall be premium efficiency.
8. Blower motors greater than 3/4 horsepower shall be "NEMA Premium" unless otherwise indicated. Compliance with EPA minimum energy-efficiency standards for single speed ODP and TE enclosures is not acceptable. Motors shall be heavy-duty, permanently lubricated type to match the fan load and furnished at the specified voltage, phase and enclosure.

E. DAMPERS

1. Motorized dampers
 - a. Frame shall be constructed of 16 gage galvanized steel hat channel. Blades shall be constructed of 16 gage galvanized steel with 1" deep Vee grooves and symmetrical about axle pivot point.
 - b. Axle bearings shall be synthetic, sleeve-type.
 - c. Blade seals shall be extruded vinyl permanently bonded to the blade edges.
 - d. Frame shall include flexible stainless steel compression type jamb seals.
 - e. Include motorized return damper for unoccupied operation.
2. Barometric relief dampers
 - a. Shall be constructed with 0.125" extruded aluminum channel frame. Blades shall be extruded aluminum and include adjustable counter-balance weights for system balancing.
 - b. Axle bearings shall be synthetic, sleeve-type.
 - c. Blade seals shall be extruded vinyl permanently bonded to the blade edges.

F. FILTERS

1. Outdoor air filter rack shall accommodate 2" MERV 13 filters. Filter section shall be accessible through a 2" foam-injected, double wall, hinged access door with quarter-turn latches.
2. Return air filter rack shall accommodate 2" MERV 8 filters. Filter section shall be accessible through a 2" foam-injected, double wall, hinged access door with quarter-turn latches.
3. Refer to Section "Particulate Air Filtration."

G. PACKAGED AIR-COOLED DX REFRIGERATION SYSTEM

1. Unit shall be provided with a complete, factory-piped, -wired, -tested, and -charged air-cooled DX cooling system. Unit shall be factory charged with R-410A refrigerant.
2. Unit shall have an integral compressor(s) and evaporator coil located within the weather-tight unit housing. Condenser coils and appurtenant condenser fan assemblies shall be factory installed as integral subassemblies of the unit and mounted on the exterior of the unit. Lead condenser fan shall have EC motor to maintain condenser pressure at part load conditions. Motors shall be UL Recognized and CSA Certified. The refrigerant compressor(s) shall be inverter hermetic scroll-type and shall be equipped with liquid line filter drier, thermostatic expansion valves (TXV)(s), manual reset high pressure and low-pressure cutouts and all appurtenant sensors, service ports and safety devices. Each compressor shall be factory-equipped with an electric crankcase heater to boil off liquid refrigerant from the oil.
3. Packaged DX Control and Diagnostics: The Packaged DX system shall be controlled by an onboard digital controller (DDC) that indicates both owner-supplied settings and fault

conditions that may occur. The DDC shall be programmed to indicate the following faults:

- a. Global alarm condition (active when there is at least one alarm)
 - b. Supply Air Proving alarm
 - c. Dirty Filter Alarm
 - d. Compressor Trip alarm
 - e. Compressor Locked Out alarm
 - f. Supply Air Temperature Low Limit alarm
 - 1) Sensor #1 Out of Range (outside air temperature)
 - 2) Sensor #2 Out of Range (supply air temperature)
 - 3) Sensor #3 Out of Range (cold coil leaving air temperature)
4. Evaporator coils shall be AHRI certified and shall be (silver) soldered or brazed into the compressed refrigerant system. Coil shall be constructed of copper tubing, permanently bonded to aluminum fins and enclosed in a galvanized steel frame. If two compressors are used as components of the unit, then the evaporator coil shall be of "interlaced" configuration, permitting independent operation of either compressor without conflict with the other compressor.
5. Coils shall be rated in accordance with ARI standards and pressure-tested for 250 psi working pressure.
6. Provide stainless steel drain pan, double-sloped to remove condensate from unit. Pan shall extend a minimum of 8" past the evaporator coil.
7. Modulating hot gas reheat:
- a. Reheat coil shall be a minimum of 6" from the evaporator coil to prevent re-evaporation of condensate, provide for coil cleaning, and allow monitoring of coil discharge temperature.
 - b. Coil shall be rated in accordance with ARI standards and pressure-tested for 250 psi working pressure.
 - c. Coil shall be constructed of copper tubes with aluminum fins mechanically bonded to the tubes and galvanized steel end casings.
 - d. Hot gas reheat shall be controlled through a factory-supply modulating control valve.
8. Compressors
- a. Compressors shall be hermetic scroll type with thermal overload protection independently circuited. Provide digital or inverter scroll compressor on lead refrigeration circuit.
 - b. Provide suction and discharge service valves.
 - c. Reverse rotation protection.
 - d. Oil level adjustment.
 - e. Rotary dirt trap.
 - f. Short cycling control.
 - g. High and low-pressure limits.
 - h. Crankcase heaters.
 - i. Compressor isolation valves.
 - j. Sight glasses.
9. Compressors shall be mounted in an isolated service compartment that can be accessed without affecting unit operation. Lockable hinged compressor access doors shall be fabricated of double wall, rigid polyurethane foam injected panels to prevent the transmission of noise outside the cabinet.

10. Compressors shall be isolated from the base pan with the compressor manufacturer's recommended rubber vibration isolators, to reduce any transmission of noise from the compressors into the building area.
11. Unit shall include a variable capacity scroll compressor on the lead refrigeration circuit which shall be capable of modulation from 10-100% of its capacity.
12. Lead refrigeration circuit shall be provided with hot gas reheat coil, modulating valves, electronic controller, supply air temperature sensor and a control signal terminal which allow the unit to have a dehumidification mode of operation, which includes supply air temperature control to prevent supply air temperature swings and overcooling of the space.
13. Provide condenser coils with galvanized casing, seamless copper tubes and aluminum fins.
14. Condenser fans shall be direct-drive, statically and dynamically balanced in accordance with AMCA Standard 205 with electrically-commutated motor. Fan assembly shall include aluminum bladed propeller fan, formed channel base, formed inlet venturi, and coated steel basket guard on the discharge.

H. ELECTRIC HEAT

1. Description: Factory standard electric heat with veneer SCR modulating electric heat for good leaving air temperature controls.

I. ENERGY RECOVERY

1. Energy wheel shall be of total enthalpy, rotary air-to-air type and shall be an element of a removable energy wheel cassette. The cassette shall consist of a galvanized steel framework, an energy wheel as specified and a motor and drive assembly. The cassette shall incorporate a pre-tensioned urethane drive belt with a five-year warranty. The wheel media shall be a polymer film matrix in a stainless steel framework and be comprised of individual segments that are removable for servicing. Non-segmented energy wheels are not acceptable. Silica gel desiccant shall be permanently bonded to the polymer film and is designed and constructed to permit cleaning and servicing. The energy wheel is to have a five-year warranty. Performance criteria are to be as specified in AHRI Standard 1060, complying with the Combined Efficiency data in the submittal.
2. Wheel operation shall be variable-speed. Wheel shall be turned off during economizer operation.
3. Unit shall include energy recovery wheel rotation detection sensors and a set of normally open and normally closed contacts for field indication of wheel rotation.

J. ELECTRICAL

1. Control panel / connections: Units shall have an electrical control center where all high and low voltage connections are made. Control center shall be constructed to permit single-point high voltage power supply connections. OAU shall be equipped with a Unit Disconnect Switch. Electric heater shall have single point power.
2. Unit shall be provided with factory installed and factory wired, non-fused disconnect switch.
3. Phase and brownout protection: Unit shall have a factory-installed phase monitor to detect electric supply phase loss and voltage brown-out conditions. Upon detection of a fault, the monitor shall disconnect supply voltage to all motors.

K. CONTROLS

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1. The unit shall be constructed so that it can function as a stand-alone heating and cooling system controlled by factory-supplied controllers, thermostats and sensors and interface with the BAS. The unit shall be controlled by a factory-installed microprocessor programmable controller (DDC) that is connected to various optional sensors.
2. Unit shall incorporate a DDC controller with integral LCD screen that provides text readouts of status. DDC controller shall have a built-in keypad to permit operator to access read-out screens without the use of ancillary equipment, devices or software. DDC controllers that require the use of equipment or software that is not factory-installed in the unit are not acceptable. Alarm readouts consisting of flashing light codes are not acceptable. Owner-specified ventilating conditions can be input by means of pushbuttons.
3. Temperature Control
 - a. Outside Air Units shall be configured to control to leaving air temperature with space temperature and humidity sensors to supply air reset optimization and to trigger unoccupied dehumidification control.
4. Unit supply fan shall be configured for Constant Volume (ON/OFF).
5. Unit exhaust fan shall be configured for Constant Volume (ON/OFF).
6. Outside Air / Return Air damper control shall be motorized and two-position.
7. Economizer control shall be temperature / enthalpy.
8. Dehumidification control shall be based on space humidity, as communicated through BAS interface. A call for dehumidification shall override occupancy status.
9. Operating protocol: The DDC shall be factory-programmed for BACnet/IP.
10. Variable Frequency Drive (VFD): unit shall have factory installed variable frequency drive for modulation of the supply and exhaust air blower assemblies. The VFD shall be factory-programmed for unit-specific requirements and shall not require additional field programming to operate.
11. Airflow monitoring: Outdoor airflow and relief airflow shall be monitored.
12. Microprocessor controller shall be mounted in a weather-proof enclosure and accessible without exposing the operator to high voltage wiring or having to turn off or circumvent the main disconnect.
13. The following sensors shall be factory supplied, mounted, and wired inside the unit:
 - a. Outdoor air humidity sensor.
 - b. Outdoor air temperature sensor.
 - c. Evaporator coil leaving air temperature sensor.
 - d. Supply air filter pressure monitoring.
 - e. Energy wheel rotation sensor.
14. The following devices shall be factory supplied but ship loose and require field installation and wiring:
 - a. Supply air temp temperature sensor.
15. BAS Interface: The BAS shall interface with the unit controls via BACnet protocol. The BAS shall enable, disable and schedule (occupied or unoccupied) the unit. The unit shall operate under its factory-provided controls once enabled.
 - a. The unit controls shall send the following points to the BAS:
 - 1) Unit status
 - 2) Alarms
 - 3) Evaporator discharge air temperature
 - 4) Unit leaving air temperature
 - b. The BAS shall send the following points to the unit controls:
 - 1) Enable/disable
 - 2) Space humidity

- c. Refer to Section 230900 and 230993 for additional interface requirements with the BAS.

L. ACCESSORIES

- 1. Hail Guards: Protects the condensing unit from damage due to extreme weather conditions such as hail and flying debris.
- 2. Condensate Overflow Switch – Shuts down unit if condensate drain line is clogged.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install condensate drain, minimum connection size, with trap and indirect connection to nearest roof drain or area drain.
- B. Duct installation requirements are specified in other HVAC Sections. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:
 - 1. Connect supply ducts to OAUs with flexible duct connectors specified in Section 233300 "Air Duct Accessories."

3.2 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
- B. Tests and Inspections:
 - 1. After installing OAUs and after electrical circuitry has been energized, test units for compliance with requirements.
 - 2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Remove and replace malfunctioning units and retest as specified above.

3.3 CLEANING AND ADJUSTING

- A. After completing system installation and testing, adjusting, and balancing OAU and air-distribution systems, clean filter housings and install new filters.

END OF SECTION 237433

SECTION 238129 - VARIABLE REFRIGERANT FLOW SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Provisions of the Contract and of the Contract Documents apply to this Section.
- B. Refer to Common Work Results for HVAC for additional requirements.

1.2 SUMMARY

- A. Section includes variable capacity, heat recovery variable refrigerant flow systems.
- B. Work includes complete variable refrigerant flow (VRF) system including equipment, piping and controls. The system shall be a simultaneous cooling and heating heat recovery system. The VRF system shall consist of air cooled condensing unit, high efficiency heat recovery units designed for minimum piping and maximum design flexibility, indoor units, and controls by the equipment manufacturer. Each indoor unit shall be independently capable of operating in either heating or cooling mode regardless of the mode of other indoor units.
- C. The variable refrigerant flow system piping system shall be designed by a manufacturer's certified designer. The contractor shall submit full piping layout to engineer, complete with locations and quantities of heat recovery units. Piping layout shall be submitted with equipment submittal for review and approval by engineer. Piping layout shall not affect performance of indoor or outdoor units.
- D. The variable refrigerant flow system piping system shall be installed by a manufacturer's certified contractor.
- E. The installing contractor shall be trained and certified at the manufacturer's training facility prior to installation, start-up, and commissioning. Submit for review the installation contractor's certification from the manufacturer. This certification shall include the company certification as well as individual certifications for each contractor which will be working on this project.
- F. The refrigeration piping system shall be provided, installed, tested, evacuated, and charged.

1.3 ACTION SUBMITTALS

- A. Submit a compliance cover letter on submittal stating that the submittal is in compliance or where deviations from the contract documents occur.
- B. Product Data: For each type of product.

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1. Include construction details, material descriptions, dimensions of individual components and profiles.
 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- C. 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.
 3. Include diagrams for power, signal, and control wiring.
- D. Coordination Drawings: Floor 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. Fan coil units, branch circuit controllers, condensing units.
- E. BAS Coordination: Equipment/system manufacturer is required to coordinate control requirements with ATC/EMS prior to submission of equipment shop drawings and letters confirming coordination are to be included with the manufacturers' submittals. Refer to section "Building Automation System". If any of the capabilities listed in the contract documents are not available in the unit and unit controller, the manufacturer shall provide alternative solution for approval to meet the intended need.
- F. Qualification Data: For Installer.
- G. Field quality-control reports.
- H. Sample Warranty: For manufacturer's warranty.
- 1.4 CLOSEOUT SUBMITTALS
- A. Operation and Maintenance Data: For outdoor units, indoor units, and controls to include in maintenance manuals.
- B. Software and Firmware Operational Documentation:
1. Software operating and upgrade manuals.
 2. Program Software Backup: On magnetic media or compact disk, complete with data files.
 3. Device address list.
 4. Printout of software application and graphic screens.
- 1.5 QUALITY ASSURANCE
- A. The units shall be listed by Electrical Testing Laboratories (ETL) and bear the ETL label.
- B. All wiring shall be in accordance with the National Electrical Code (N.E.C.).

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- C. The units shall be manufactured in a facility registered to ISO 9001 and ISO14001 which is a set of standards applying to environmental protection set by the International Standard Organization (ISO).
- D. All units must meet or exceed the 2010 Federal minimum efficiency requirements and the ASHRAE 90.1 efficiency requirements for VRF systems. Efficiency shall be published in accordance with the Air-Conditioning, Heating, and Refrigeration Institute (AHRI) Standard 1230.
- E. A full charge of R-410A for the condensing unit only shall be provided in the condensing unit.
- F. Manufacturers Field Service - Engage a factory-authorized service representative to inspect field assembled components and equipment installation, including connections, and to assist in field testing.
- G. The refrigeration piping system shall be provided, installed, tested, evacuated and charged in accordance with the manufacturer's recommendations, ANSI, ASHRAE, and ARI's Safety Code for Mechanical Refrigeration, state and local codes.
- H. Perform the following field tests and inspections and prepare test reports:
 - 1. Leak Test - After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Operational Test - After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- I. Remove and replace malfunctioning units and retest as specified above.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Units shall be stored and handled according to the manufacturer's recommendation.

1.7 WARRANTY

- A. All units shall be covered by an extended manufacturer's limited warranty for a period of ten (10) years to the original owner from date of substantial completion. In addition, the compressor shall have a manufacturer's limited warranty for a period of ten (10) years to the original owner from date of installation. If, during this period, any part should fail to function properly due to defects in workmanship or material, it shall be replaced or repaired at the discretion of the manufacturer. This warranty shall not include labor.
- B. All manufacturer technical and service manuals must be readily available for download by any local contractor should emergency service be required. Registering and sign-in requirements which may delay emergency service reference are not allowed.

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- C. The VRF system shall be installed by a contractor with extensive install and service training for the provided manufacturer. The mandatory contractor service and install training should be performed by the manufacturer.
- D. Within the first two years after substantial completion, warranty items shall warrant a response within 24 hours from contact of owner. Labor and refrigerant shall be included in the warranty in the first two years after substantial completion.

1.8 SERVICE

- A. The contractor performing work under this section shall provide all preventative maintenance on the equipment for a period of two (2) years after substantial completion.
- B. Preventative maintenance shall include a minimum service four (4) times per year or as recommended by the unit manufacturer, whichever is more, for the first two years. All parts, materials, and labor shall be included.

1.9 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed, are packaged with protective covering for storage, and are identified with labels describing contents.
 - 1. One set of matched fan belts for each belt-driven fan.
 - 2. Where Merv-11 filters are required, provide nine sets of spare filters.
 - 3. One set of spare fuses, three of each type for all equipment variable frequency drives.
 - 4. Provide allen keys, socket set, and any additional small tools required for equipment access panels as required for general maintenance work.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Carrier.
 - 2. Daikin.
 - 3. Trane/ Mitsubishi.
- B. Coordinate any changes from the basis of design with all associated trades. Any additional costs associated with the alternate equipment shall be covered by the equipment manufacturer. No additional costs shall be incurred by the Owner.

2.2 REFRIGERANT COMPONENTS

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- A. The equipment specified in this section shall operate with refrigerant R410A – no exceptions or substitutions.
- B. The system shall utilize fully modulating electronic expansion valves.
- C. Refrigerant Piping
 - 1. The refrigerant piping system shall be provided complete and installed in accordance with the manufacturer's recommendations and as specified herein. The size of the refrigerant pipes shall be obtained from the equipment manufacturer unless otherwise shown on the drawings.
 - 2. Pipe, Fittings, and Accessories - The pipe shall be type ACR 'L' hard drawn copper refrigerant tubing with hard wrought copper fittings. All of the joints shall be brazed with a filler material that complies with AWS classification BCuP-5. A sight glass with moisture indicator shall be provided if not provided with equipment. Use type 'L' copper tubing to pipe the relief valve discharge to the outside.
 - 3. All refrigerant lines shall be insulated from the condensing unit to the indoor terminal units.

2.3 CONDENSATE DRAIN PIPING

- A. Condensate Drain Piping:
 - 1. Refer to Section “Hydronic Piping” for condensate drain piping requirements.
 - 2. Refer to Section “Hydronic Pumps” for condensate pump requirements.

2.4 CONDENSING UNITS (HEAT PUMPS)

- A. General: The outdoor unit is designed specifically for use with VRF series components.
 - 1. The outdoor unit shall be factory assembled and pre-wired with all necessary electronic and refrigerant controls. The refrigeration circuit of the condensing unit shall consist of a swing compressor, motors, fans, condenser coil, electronic expansion valves, solenoid valves, 4-way valve, distribution headers, capillaries, filters, shut off valves, oil separator, service ports and suction line accumulator.
 - 2. The connection ratio of indoor units to outdoor unit shall be in accordance with the manufacturer's limits.
 - 3. The system will automatically restart operation after a power failure and will not cause any settings to be lost, thus eliminating the need for reprogramming.
 - 4. The outdoor unit shall allow for side-by-side installation with minimum spacing.
 - 5. The following safety devices shall be included on the condensing unit; high pressure switch, low pressure sensor, control circuit fuses, crankcase heaters, fusible plug, overload relay, inverter overload protector, thermal protectors for compressor and fan motors, over current protection for the inverter and anti-recycling timers.
 - 6. To ensure the liquid refrigerant does not flash when supplying to the various indoor unit units, the circuit shall be provided with a sub-cooling feature or as required by the manufacturer to manage all refrigerant.
 - 7. Oil recovery cycle shall be automatic occurring 2 hours after start of operation and then every 8 hours of operation or as required by the manufacturer.

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8. The outdoor unit shall be capable of heating operation at 0°F dry bulb ambient temperature.
- B. Unit Cabinet:
1. The outdoor unit shall be completely weatherproof and corrosion resistant. The unit shall be constructed from rust-proofed mild steel panels coated with a baked enamel finish.
- C. Fan:
1. The condensing unit fan(s) shall consist of propeller type, direct-drive fan motors that have multiple speed operation via a DC (digitally commutating) inverter.
 2. The fan shall be a horizontal discharge configuration.
 3. The fan motor shall have inherent protection and permanently lubricated bearings and be mounted.
 4. The fan motor shall be provided with a fan guard to prevent contact with moving parts.
- D. Condenser Coil:
1. The condenser coil shall be manufactured from copper tubes expanded into aluminum fins to form a mechanical bond.
 2. The heat exchanger coil shall be of a waffle louver fin and rifled bore tube design to ensure high efficiency performance.
 3. The heat exchanger on the condensing units shall be manufactured from Hi-X seamless copper tube.
 4. The fins are to be covered with an anti-corrosion acrylic resin and hydrophilic film type E1.
- E. Compressor:
1. The inverter scroll compressor shall be variable speed controlled which is capable of changing the speed to follow the variations in total cooling and heating load as determined by the suction gas pressure as measured in the condensing unit. In addition, samplings of evaporator and condenser temperatures shall be made so that the high/low pressures detected are read every 20 seconds and calculated. With each reading, the compressor capacity shall be controlled to eliminate deviation from target value.
 2. The inverter driven compressor in each condensing unit shall be of highly efficient reluctance DC (digitally commutating), hermetically sealed swing type.
 3. Neodymium magnets shall be adopted in the rotor construction to yield a higher torque and efficiency in the compressor instead of the normal ferrite magnet type. At complete stop of the compressor, the neodymium magnets will position the rotor into the optimum position for a low torque start.
 4. The capacity control range shall be 14% to 100%.
 5. The compressor shall be equipped with a crankcase heater, high pressure safety switch, and internal thermal overload protector.
 6. Oil separators shall be standard with the equipment together with an intelligent oil management system.
 7. The compressor shall be mounted to the structure by neoprene mounts to avoid the transmission of vibration.
- F. Electrical:
1. The power supply to the outdoor unit shall be 208/230 volts, 1 phase, 60 hertz +/- 10%.
 2. The control voltage between the indoor and outdoor unit shall be 18VDC non-shielded, stranded 2 conductor cable.

3. The control wiring shall be a two-wire multiplex transmission system, making it possible to connect multiple indoor units to one outdoor unit with one 2-cable wire, thus simplifying the wiring operation.

2.5 CONDENSING UNITS (HEAT RECOVERY)

A. GENERAL:

1. The condensing unit is designed specifically for use with VRF series components.
2. The condensing unit shall be factory assembled and pre-wired with all necessary electronic and refrigerant controls.
3. The refrigeration circuit of the condensing unit shall consist of inverter flash vapor injection scroll compressors, motors, fans, condenser coil, electronic expansion valves, solenoid valves, 4-way valve, distribution headers, capillaries, filters, shut off valves, oil separators, service ports, liquid receiver and suction accumulator.
4. The connection ratio of indoor units to condensing unit shall be as recommended by the manufacturer.
5. The system will automatically restart operation after a power failure and will not cause any settings to be lost, thus eliminating the need for reprogramming.
6. The condensing unit shall be modular in design and should allow for side-by-side installation.
7. The following safety devices shall be included on the condensing unit; high pressure sensor and switch, low pressure sensor, control circuit fuses, crankcase heaters, fusible plug, overload relay, inverter overload protector, thermal protectors for compressor and fan motors, over current protection for the inverter and anti-recycling timers.
8. To ensure the liquid refrigerant does not flash when supplying to the various indoor units, the circuit shall be provided with a sub-cooling feature or other controls as required by the manufacturer.
9. Oil recovery cycle shall be automatic occurring 2 hours after start of operation and then every 8 hours of operation. Each system shall maintain continuous heating during oil return operation or other sequence as required by the manufacturer.
10. The condensing unit shall be capable of heating operation at -22°F WB (-20°C WB) ambient temperature without additional low ambient controls or an auxiliary heat source.
11. The multiple condenser VRF systems shall continue to provide heat to the indoor units in heating operation while in the defrost mode.

B. UNIT CABINET:

1. The condensing unit shall be completely weatherproof and corrosion resistant. The unit shall be constructed from rust-proofed mild steel panels coated with a baked enamel finish.

C. FAN:

1. The condensing unit shall consist of one or more propeller type, direct-drive 350, 400 or 800W fan motors that have multiple speed operation via a DC (digitally commutating) inverter.
2. The condensing unit fan motor shall have multiple speed operation of the DC (digitally commutating) inverter type, and be of high external static pressure and shall be factory set as standard at 0.12 in. WG. A field setting switch to a maximum 0.32 in. WG pressure is available to accommodate field applied duct for indoor mounting of condensing units.

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3. The fan shall be a vertical discharge configuration.
4. The fan motor shall have inherent protection and permanently lubricated bearings and be mounted.
5. The fan motor shall be provided with a fan guard to prevent contact with moving parts.

D. Sound:

1. Nominal sound pressure levels shall be as shown below.

MODEL NUMBER	SOUND PRESSURE LEVEL dB(A)
RELQ72TAYD*	60
RELQ96TAYD*	61
RELQ120TAYD*	63.5
RELQ144TAYD*	63
RELQ192TAYD*	64
RELQ240TAYD*	67

E. Condenser Coil:

1. The condenser coil shall be manufactured from copper tubes expanded into aluminum fins to form a mechanical bond.
2. The heat exchanger coil shall be of a waffle louver fin and rifled bore tube design to ensure high efficiency performance.
3. The heat exchanger on the condensing units shall be manufactured from Hi-X seamless copper tube with N-shape internal grooves mechanically bonded on to aluminum fins to an e-Pass Design.
4. The fins shall be coated with an anti-corrosion hydrophilic blue coating as standard from factory with a salt spray test rating of 1000hr per ASTM test standards.
5. The outdoor coil shall have three-circuit heat exchanger design eliminating the need for a drain pan heater. The lower part of the coil shall be used for inverter cooling and be on or off during heating operation enhancing the defrost operation.
6. An alternate manufacturer must provide a drain pan heater to enable adequate defrosting of the unit in defrost operation or similar controls to defrost coil.
7. The condensing unit shall be factory equipped with condenser coil guards on all sides.

F. COMPRESSOR:

1. The inverter injection scroll compressors shall be variable speed controlled which is capable of changing the speed to follow the variations in total cooling and heating load as determined by the suction gas pressure as measured in the condensing unit.
2. In addition, samplings of evaporator and condenser temperatures shall be made so that the high/low pressures detected are read every 20 seconds and calculated. With each reading, the compressor capacity (INV frequency) shall be controlled to eliminate deviation from target value.
3. The inverter driven compressors in the condensing unit shall be of highly efficient reluctance DC (digitally commutating), hermetically sealed scroll "K-type".
4. Neodymium magnets shall be adopted in the rotor construction to yield a higher torque and efficiency in the compressor instead of the normal ferrite magnet type.
5. At complete stop of the compressor, the neodymium magnets will position the rotor into the optimum position for a low torque start.
6. The capacity control range shall be as low as 4.3% to 100%.
7. The compressor's motor shall have a cooling system using discharge gas, to avoid sudden changes in temperature resulting in significant stresses on winding and bearings.

8. Each compressor shall be equipped with a crankcase heater, high pressure safety switch, and internal thermal overload protector.
9. Oil separators shall be standard with the equipment together with an intelligent oil management system.
10. The compressor shall be mounted on vibration dampening rubber grommets to minimize the transmission of vibration, eliminating the standard need for external spring isolation.
11. In the event of compressor failure, the remaining compressors shall continue to operate and provide heating or cooling as required at a proportionally reduced capacity. The microprocessor and associated controls shall be manually activated to specifically address this condition for single module and manifold systems.
12. In the case of multiple condenser modules, combined operation hours of the compressors shall be balanced by means of the Duty Cycling Function, ensuring sequential starting of each module at each start/stop cycle, completion of oil return, completion of defrost or every 8 hours. When connected to a central control system sequential start is activated for all system on each network.

2.6 BRANCH CIRCUIT CONTROLLERS

A. General:

1. The branch circuit controllers shall include multiple branches to allow simultaneous heating and cooling by allowing either hot gas refrigerant to flow to indoor unit(s) for heating or subcooled liquid refrigerant to flow to indoor unit(s) for cooling. Refrigerant used for cooling must always be subcooled for optimal indoor unit LEV performance.
2. The BC (Branch Circuit) Controllers shall be specifically used with R410A and matched with the condensing units. These units shall be equipped with a circuit board that interfaces to the controls system and shall perform all functions necessary for operation. The unit shall have a galvanized steel finish. The BC Controller shall be completely factory assembled, piped and wired. Each unit shall be run tested at the factory. This unit shall be mounted indoors, with access and service clearance provided for each controller. The sum of connected capacity of all indoor air handlers shall range from 50% to 150% of rated capacity. The BC Controller shall be suitable for use in plenums.

B. BC Unit Cabinet:

1. The casing shall be fabricated of galvanized steel.
2. Each cabinet shall house a liquid-gas separator and multiple refrigeration control valves.
3. The unit shall house two tube-in-tube heat exchangers.

C. Refrigerant

1. R410A refrigerant shall be required.

D. Refrigerant Branches

1. All BC Controller refrigerant pipe connections shall be brazed or flared.

E. Refrigerant valves:

1. The unit shall be furnished with multiple branch circuits which can individually accommodate up to 54,000 BTUH and up to three indoor units. Branches may be twinned to allow more than 54,000 BTUH.
2. Each branch shall have multiple two-position valves to control refrigerant flow.
3. Service shut-off valves shall be field-provided/installed for each branch to allow service to any indoor unit without field interruption to overall system operation.
4. Linear electronic expansion valves shall be used to control the variable refrigerant flow.

F. Integral Drain Pan:

1. An integral resin drain pan and drain shall be provided if required by the manufacturer.

G. Electrical:

1. The unit electrical power shall be 208/230 volts, 1 phase, 60 Hertz.
2. The BC Controller shall be controlled by integral microprocessors
3. The control circuit between the indoor units and outdoor units shall be 24VDC completed using a 2-conductor, twisted pair shielded cable to provide total integration of the system.

2.7 INDOOR FAN COIL UNITS

A. PLFY – FOUR-WAY CEILING-RECESSED CASSETTE WITH GRILLE

1. General
 - a. Four-way cassette style indoor unit that recesses into the ceiling with a ceiling grille. The indoor unit shall be factory assembled, wired and run tested. Contained within the unit shall be all factory wiring, piping, electronic modulating linear expansion device, control circuit board and fan motor. The unit shall have a self-diagnostic function, 3-minute time delay mechanism, an auto restart function, an emergency operation function and a test run switch. Indoor unit and refrigerant pipes shall be charged with dehydrated air before shipment from the factory.
2. Unit Cabinet:
 - a. The cabinet shall be a compact 22-7/16" wide x 22-7/16" deep so it will fit within a standard 24" square suspended ceiling grid.
 - b. The cabinet panel shall have provisions for a field installed filtered outside air intake.
 - c. Four-way grille shall be fixed to bottom of cabinet allowing two, three or four-way blow.
3. Fan:
 - a. The indoor fan shall be an assembly with a turbo fan direct driven by a single motor.
 - b. The indoor fan shall be statically and dynamically balanced to run on a motor with permanently lubricated bearings.
 - c. The indoor fan shall consist of three (3) speeds, Low, Mid, and High.
 - d. The indoor unit shall have an adjustable air outlet system offering 4-way airflow, 3-way airflow, or 2-way airflow.
 - e. The auto air swing vanes shall be capable of automatically swinging up and down for uniform air distribution.
4. Filter:

- a. Return air shall be filtered by means of a long-life washable filter.
5. Coil:
 - a. The indoor coil shall be of nonferrous construction with smooth plate fins on copper tubing.
 - b. The tubing shall have inner grooves for high efficiency heat exchange.
 - c. All tube joints shall be brazed with phos-copper or silver alloy.
 - d. The coils shall be pressure tested at the factory.
 - e. A condensate pan and drain shall be provided under the coil.
 - f. The unit shall be provided with an integral condensate lift mechanism that will be able to raise drain water 19-3/4" inches above the condensate pan.
 - g. Both refrigerant lines to the PLFY indoor units shall be insulated in accordance with the installation manual.
6. Electrical:
 - a. The unit electrical power shall be 208/230 volts, 1-phase, 60 hertz.
 - b. The system shall be capable of satisfactory operation within voltage limits of 187-228 volts (208V/60Hz).
7. Controls:
 - a. This unit shall use controls provided by Mitsubishi Electric to perform functions necessary to operate the system.
 - b. Indoor unit shall compensate for the higher temperature sensed by the return air sensor compared to the temperature at level of the occupant when in HEAT mode. Disabling of compensation shall be possible for individual units to accommodate instances when compensation is not required.
 - c. Control board shall include contacts for control of external heat source. External heat may be energized as second stage with 1.8°F – 9.0°F adjustable deadband from set point.
 - d. Indoor unit shall include no less than four (4) digital inputs capable of being used for customizable control strategies.
 - e. Indoor unit shall include no less than three (3) digital outputs capable of being used for customizable control strategies.

B. CEILING-CONCEALED DUCTED UNIT

1. General:
 - a. The PEFY shall be a ceiling-concealed ducted indoor fan coil design that mounts above the ceiling with a 2-position, field adjustable return and a fixed horizontal discharge supply and shall have a modulating linear expansion device. The PEFY shall be used with the R2-Series outdoor unit and BC Controller, Y-Series outdoor unit, or S-Series outdoor unit. The PEFY shall support individual control using M-NET DDC controllers. The unit shall be suitable for use in plenums in accordance with UL1995 Ed 4.
2. Indoor Unit.
 - a. The indoor unit shall be factory assembled, wired and run tested. Contained within the unit shall be all factory wiring, piping, electronic modulating linear expansion device, control circuit board and fan motor. The unit shall have a self-diagnostic function, 3-minute time delay mechanism, and an auto restart function. Indoor unit and refrigerant pipes shall be charged with dehydrated air before shipment from the factory.

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3. Unit Cabinet:
 - a. The unit shall be, ceiling-concealed, ducted.
 - b. The cabinet panel shall have provisions for a field installed filtered outside air intake.
4. Fan:
 - a. PEFY-NMAU models shall feature external static pressure settings from 0.14 to 0.60 in. WG.
 - b. The indoor unit fan shall be an assembly with one or two Sirocco fan(s) direct driven by a single motor.
 - c. The indoor fan shall be statically and dynamically balanced and run on a motor with permanently lubricated bearings.
 - d. The indoor fan shall consist of three (3) speeds, High, Mid, and Low plus the Auto-Fan function
 - e. The indoor unit shall have a ducted air outlet system and ducted return air system.
5. Filter:
 - a. Return air shall be filtered by means of a standard factory installed return air filter.
 - b. Optional return filter box (rear or bottom placement) with high-efficiency filter shall be available for all PEFY indoor units and be included.
6. Coil:
 - a. The indoor coil shall be of nonferrous construction with smooth plate fins on copper tubing.
 - b. The tubing shall have inner grooves for high efficiency heat exchange.
 - c. All tube joints shall be brazed with phos-copper or silver alloy.
 - d. The coils shall be pressure tested at the factory.
 - e. A condensate pan and drain shall be provided under the coil.
 - f. The condensate shall be gravity drained from the fan coil.
 - g. Both refrigerant lines to the PEFY indoor units shall be insulated in accordance with the installation manual.
7. Electrical:
 - a. The unit electrical power shall be 208/230 volts, 1-phase, 60 hertz.
 - b. The system shall be capable of satisfactory operation within voltage limits of 187-228 volts (208V/60Hz).
8. Controls:
 - a. This unit shall use controls provided by Mitsubishi Electric Cooling & Heating to perform functions necessary to operate the system. Please refer to Part 5 of this guide specification for details on controllers and other control options.
 - b. Indoor unit shall compensate for the higher temperature sensed by the return air sensor compared to the temperature at level of the occupant when in HEAT mode. Disabling of compensation shall be possible for individual units to accommodate instances when compensation is not required.
 - c. Control board shall include contacts for control of external heat source. External heat may be energized as second stage with 1.8°F – 9.0°F adjustable dead band from set point.
 - d. Indoor unit shall include no less than four (4) digital inputs capable of being used for customizable control strategies.
 - e. Indoor unit shall include no less than three (3) digital outputs capable of being used for customizable control strategies.

2.8 CONTROLS

A. General:

1. The control system shall consist of a low voltage communication network of unitary built-in controllers with on-board communications and a web-based operator interface. A web controller with a network interface card shall gather data from this system and generate web pages accessible through a conventional web browser on each PC connected to the network. Operators shall be able to perform all normal operator functions through the web browser interface.
2. System controls and control components shall be installed in accordance with the manufacturer's written installation instructions.
3. Furnish energy conservation features such as optimal start, night setback, request-based logic, and demand level adjustment of overall system capacity as specified in the sequence.
4. System shall provide direct and reverse-acting on and off algorithms based on an input condition or group conditions to cycle a binary output or multiple binary outputs.
5. Provide capability for future system expansion to include monitoring and use of occupant card access, lighting control and general equipment control.
6. System shall be capable of email generation for remote alarm annunciation.
7. Control system start-up shall be a required service to be completed by the manufacturer or a duly authorized, competent representative that has been factory trained in the Manufacturer's controls system configuration and operation. The representative shall provide proof of certification for Training indicating successful completion of no more than two (2) years prior to system installation. This certification shall be included as part of the equipment and/or controls submittals. This service shall be equipment and system count dependent and shall be a minimum of one (1) eight (8) hour period to be completed during normal working hours.
8. The Controls Network shall be capable of supporting remote controllers, centralized controllers, an integrated web based interface, graphical user workstation, and system integration to Building Management Systems via BACnet[®] and LonWorks[®].

B. Building Automation System Integration:

1. BAS Coordination: Refer to Section "Building Automation System".
 - a. Factory OEM controller shall have an Occupied/Unoccupied input point and a separate Emergency Shutdown input point. OEM control systems must be able to provide 2 input separate inputs for EMS contractor to perform these functions.
 - b. An EMS reset relay input shall be supplied on the factory supplied terminal strip to permit remote cycling of power to the OEM controller for EMS for remote reboot.
 - c. EMS contractor shall provide all available temperature sensors via hardwired EMS in addition to the same points in BACnet including supply air, return air, mixed air, exhaust air, and DX coil temperature.
 - d. EMS contractor shall provide via hardwired EMS points for occupied/unoccupied command, emergency shutdown, controller remote reset, fan status(s), supply temperature, return temperature and where applicable mixed air temperature sensors.
 - e. For all of these duplicate points show both points on graphics (BACnet in gray test, EMS in black).
 - f. If any of these capabilities are not available in the packaged unit, the manufacturer shall provide alternative solution for approval to meet the intended need.

1. Advanced HVAC Controller (AHC)
 - a. The AHC shall be capable of providing programmable binary and analog inputs and outputs to control general equipment in conjunction with indoor unit functions and states. Input and output states and values shall be monitored through the Centralized Controller or the Remote controller. The Smart ME remote controller shall be able to adjust temperature and humidity set points for equipment controlled by the AHC. In addition to analog and binary inputs the AHC can monitor M-NET equipment states and sensor values. Available inputs include room temperature, room humidity, occupancy, brightness, outdoor temperature, inlet/outlet water temperature (PWFY), on/off state, mode, ventilation on/off, error status. In addition to programmable analog and binary outputs, the AHC can control indoor unit on/off, mode, temperature set point, fan speed, LOSSNAY on/off and LOSSNAY fan speed.

I. Centralized Controller

1. The Centralized Controller shall be capable of controlling a maximum of two hundred (200) indoor units across multiple condensing units with the use of expansion controllers. The Centralized Controller shall be approximately 11-5/32" x 7-55/64" x 2-17/32" in size and shall be powered with an integrated 100-240 VAC power supply. The Centralized Controller shall support system configuration, daily/weekly scheduling, monitoring of operation status, night setback settings, free contact interlock configuration and malfunction monitoring. When being used alone without the expansion controllers, the Centralized Controller shall have five basic operation controls which can be applied to an individual indoor unit, a collection of indoor units (up to 50 indoor units), or all indoor units (collective batch operation). This basic set of operation controls for the Centralized Controller shall include on/off, operation mode selection (cool, heat, auto, dry, setback, and fan), temperature setting, fan speed setting, and airflow direction setting. The Centralized Controller shall be able to enable or disable operation of local remote controllers. In terms of scheduling, the Centralized Controller shall allow the user to define both daily and weekly schedules (up to 24 scheduled events per day) with operations consisting of ON/OFF, mode selection, temperature setting, air flow (vane) direction, fan speed, and permit/prohibit of remote controllers.
2. All Centralized Controllers shall be equipped with two RJ-45 Ethernet ports to support interconnection with a network PC via a closed/direct Local Area Network (LAN) or to a network switch for IP communication to up to three expansion controllers for display of up to two hundred (200) indoor units on the main interface.
3. The Centralized Controller shall be capable of performing initial settings via the high-resolution, backlit, color touch panel on the controller or via a PC browser using the initial settings.
4. Standard software functions shall be available so that the building manager can securely log into each via the PC's web browser to support operation monitoring, scheduling, error email, interlocking and online maintenance diagnostics.
5. Centralized controller shall have interface screen or computer for diagnostics. Provide service interface tool and software to accomplish all monitoring and maintenance diagnostics specified in "Maintenance Tool Software"

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install Centralized controller for the entire VRF system. Install controls in accordance with schematics on drawings.
- B. Install all piping, fittings, and insulation to meet manufacturer's requirements. Install units level and plumb. Evaporator-fan components shall be installed using manufacturers standard mounting devices securely fastened to building structure. Install and connect refrigerant tubing and fittings.
- C. Locate indoor and outdoor units as indicated on drawings. Provide service clearance per manufacturer's installation manual. Adjust and level outdoor units on support structure. Mount the outdoor unit a minimum of 12" above average snowfall.
- D. Components/Piping:
 - 1. Installing contractor shall provide and install all accessories and piping for a fully operational system. Refer to manufacturer's installation manual for full instructions.
 - 2. Traps, filter driers, and sight glasses are NOT to be installed on the refrigerant piping or condensate lines.
 - 3. Standard ACR fittings rated for use with R410A are to be used for all connections. Proprietary manufacturer-specific appurtenances are not allowed.
 - 4. Refrigerant pipe for CITY MULTI shall be made of phosphorus deoxidized copper, and has two types.
 - a. ACR "Annealed": Soft copper pipe, can be easily bent with human's hand.
 - b. ACR "Drawn Temper": Hard copper pipe (Straight pipe), being stronger than Type-O pipe of the same radical thickness.
 - 5. The maximum operation pressure of R410A air conditioner is 623psi (or as indicated by manufacturer) . The refrigerant piping should ensure the safety under the maximum operation pressure. Refer to recommend piping specifications in manufacturer's engineering manual. Pipes of radial thickness 0.7mm or less shall not be used.
 - 6. Flare connection should follow dimensions provided in manufacturer's installation manuals.
- E. Insulation - Refrigerant lines, as well as any valves, shall be insulated end to end with ½" closed-cell pipe insulation for piping up to 1" in diameter, or ¾" for piping 1-1/8" and larger, with a thermal conductivity no greater than 0.27 BTU-in/hr sq.ft °F. If the manufacturer, state or local codes require insulation other than that specified above, the greater insulation shall be used.
- F. Electrical - Installing contractor shall coordinate electrical requirements and connections for all power feeds with electrical contractor. Refer to Division 26 for additional information
- G. Installer shall supply isolation ball valves for zoned refrigerant isolation. Installer shall supply Isolation ball valves with Schrader connection for isolating refrigerant charge and evacuation at each connected indoor unit and condensing unit. Isolation ball valves, with Schrader connection, are required for instances of indoor unit isolation for troubleshooting, repair, or replacement without affecting the remainder of the system. Isolation ball valves with Schrader

connection are also required at condensing unit connection to isolate unit for troubleshooting, repair or replacement and as required to provide partial capacity Heating/Cooling in the instance of a failure of one of the multiple outdoor unit (condensing unit) compressors.

- H. During brazing an inert gas (such as nitrogen) shall be continuously passed through the system at a rate sufficient to maintain an oxygen free environment to prevent the formation of copper oxide scale. After piping has been completed, the refrigerant piping system shall be pressure tested at a pressure of 300 psi on the high side and 150 psi on the low side. The pressure shall be maintained on the system for a minimum of 12 hours. The system shall be evacuated when the surrounding ambient air is not less than 60 F. If the temperature is less, auxiliary heat must be provided to insure proper evacuating conditions. A minimum vacuum of 500 Microns of Hg. shall be pulled on the system and maintained for 12 hours. The vacuum pump displacement shall be not less than 2 cfm for up to 15 tons. The system shall be charged as recommended by the equipment manufacturer.
- I. Electrical wiring required by this section, both high and low voltage, shall comply with the Division 26 requirements.
- J. Start Up - Engage manufacturer or factory-authorized service representative with minimum 40 hours of factory training to perform startup service. Manufacturer shall provide on-site startup and commissioning assistance through job completion. Complete installation and startup checks according to manufacturer's written instructions. This shall include a factory startup for factory provided control devices as well as configuring control points for other DO devices. Service representative shall completely configure all control devices and establish remote internet connectivity with the owner's energy management department web server.
- K. Demonstration - Engage manufacturer or factory-authorized service representative to train Owners maintenance personnel to adjust, operate and maintain individual units and complete system.
- L. The indoor air handling and outside condensing units shall be installed in accordance with the manufacturer's recommendations and as shown on the drawings. The first unit installed of each type will be considered the typical mock up and shall require notification, inspection and approval by the designated owner's representative before any additional installations will be allowed.
- M. Provide a typed list of all the different units, their filter sizes, and belt sizes to be included in the O&M manuals. The list shall include the unit designation, filter size, belt size, and the number of filters and belts required for each unit.

3.2 MAINTENANCE TOOL SOFTWARE

- A. The Maintenance Tool shall enable the user to monitor and record the following parameters in a centralized system.
- B. Outdoor Unit
 1. Operation Mode (Cooling Only, Heating Only, Cooling Main, Heating Main)
 2. Compressor Frequency, amperages, and voltages
 3. Compressor high- and low-side pressure

4. System Temperatures
 5. Outdoor temperature
 6. Status of reversing valve
- C. BC Controller
1. Valve ON/OFF status
 2. Temperatures
 3. Pressures
- D. Indoor Unit
1. Entering Air Temperature
 2. Entering/Leaving Refrigerant Temperature
 3. Superheat/Subcool temperatures
 4. LEV position
 5. Room temperature setpoint
 6. Unit Mode and Status (Heat, Cool, Dry, Auto, Fan)
- E. The Maintenance Tool shall have the additional feature of controlling the following system components manually:
- F. Indoor Unit
1. Indoor Unit ON/OFF
 2. Mode (Heat, Cool, Dry, Auto, Fan)
 3. Room Temperature Setpoint
 4. Fan speed
 5. LEV Position
- G. BC Controller
1. Valve OPEN/CLOSE
 2. LEV Position
- H. The Maintenance Tool shall be connectable to either the TB3 or TB7 communication bus lines on the network via alligator connectors.
- I. The maintenance tool/centralized controller shall have a screen interface or be provided with a computer if required for monitoring of the maintenance tool functions.
- J. The Maintenance Tool shall be connectable to a PC via a USB cable.
- K. Trended data from Maintenance Tool shall be available to export to a data file for offline analysis.

3.3 IDENTIFICATION

- A. Label each air terminal unit with tag, nominal airflow, and maximum and minimum factory set airflows. Comply with requirements in section "Identification for HVAC Piping and Equipment" for equipment labels and warning signs/labels.

3.4 VRF PROJECT SUPERVISION

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A. General

1. VRF Manufacturer shall provide on-site *Project Supervision* as outlined in this specification section, providing: onsite technical review of installed VRF systems, review of activities related to the installation of the VRF system, VRF system components and associated controls.
2. All *Project Supervision* field activities shall be completed by an employee of the VRF manufacturer whose primary job responsibilities are to provide direct technical support of their product; sales staff or in-house support staff are not permitted to complete this scope of work.
3. A factory certified representative may assist the VRF manufacturer's personnel in the completion of certain elements of work contained within this specification. Activities completed by a Factory Certified Representative shall be supervised onsite by the VRF manufacturer. Certified representatives shall not be used in lieu of the manufacturer's personnel.
4. The installing contractor shall assist the VRF manufacturer, in their completion of the system review and have available onsite a technician with appropriate diagnostic tools, materials and equipment, as required, for the duration of the inspection process. The technician assisting the VRF manufacturer shall be fully licensed and insured to complete necessary duties as directed by the VRF manufacturer.
5. The installing contractor shall have been certified by the manufacturer to install VRF systems, having attended and successfully completed a minimum 3- day VRF Service & Installation course at an approved training facility. A copy of this certificate shall be presented to the VRF manufacturer prior to the commencement of installation activity.
6. VRF manufacturer shall provide 4 onsite visits during the course of the project's completion. Additional site visits, if requested, shall require approval by the owner's representative and will be billed accordingly.
7. Onsite visits shall be conducted at installation milestones noted below. The installing contractor is responsible to coordinate each visit at the appropriate milestone, giving the VRF manufacturer a minimum 2-week notice prior to each visit.
 - a. Project milestones
 - 1) Project Kick Off meeting
 - 2) Site Visit at 25% project completion
 - 3) Site Visit at 50% project completion
 - 4) Final Inspection prior to Commissioning of the VRF System

B. Project Kick-Off

1. A project kick off meeting will be conducted with the installing contractor and appropriate parties with the sole purpose to review the installation of VRF systems being installed.
2. Kick off meeting shall consist of a single meeting with the installing contractor. This meeting shall be completed at the project site and be executed at the beginning stages of the installation of VRF systems.
 - a. Items to be reviewed during the Project kick-off meeting are:
 - 1) Presentation of Best Practices & Installation Requirements specific to the VRF system(s) being installed under this scope of work.
 - 2) Review of the project's mechanical design drawings related to the VRF systems being installed. Documents to be provided by the mechanical contractor.

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- 3) Review of VRF Manufacturers design selection software and system design schematic drawings for the system being installed Documents to be provided by the mechanical contractor.
 - 4) Discuss project activity related to the installation of VRF system components
 - 5) Establish clear path of communication and project support. Mechanical contractor shall designate an onsite point of contact for all field coordination activities.
3. The installing contractor shall obtain from the Engineer/Designer of the VRF system a copy of the most current electronic design file used in the design and engineering process of the VRF system being installed. This electronic design file shall have been completed on the VRF Manufacturers software and is the mechanical contractor's responsibility to provide the most current as-built version of this file during the course of the projects installation.
 4. The installing contractor shall provide the VRF manufacturer, for their use, a complete set of HVAC mechanical plans prior to the Kick off meeting. The mechanical contractor is responsible to updates these plans during the course of the project.

C. Site Visit

1. Each site visit shall consist of a single visit, not exceeding an 8 hour period. All visits shall occur during regular business hours of 8:30AM-4PM, Monday thru Friday.
2. Activates to be completed during each Site-Visit are as follows:
 - a. Meet with designated representative from the VRF installation contractor to discuss field activities and provide technical support related to the VRF systems.
 - b. Review installed VRF systems for compliance with manufacturer's installation, service and engineering specifications.
 - c. Assist the contractor in updating the VRF Design software for as-built purposes and for calculating the appropriate refrigerant charge.
 - d. Provide a field report identifying any installation issues requiring attention. Report shall provide detailed information containing:
 - 1) Issue reference number
 - 2) Priority Level of issue
 - 3) Equipment M# & Reference TAG#
 - 4) Status of issue
 - 5) Description of issue being identified
 - 6) Recommendation for corrective action
 - 7) Follow-up requirements, if required

D. Project Closeout

1. Documents completed during the project Supervision process shall be compiled and presented to the owner's representative at the completion of field activities.
2. Close out documentation shall include
 - a. Project Supervision report outlining activities completed under this scope of work
 - b. As-built VRF design file depicting Model numbers and BTU capacity ratings of equipment installed, refrigerant pipe size & connection lengths between each system component, calculated refrigerant charge.
 - c. Issue report

3.5 VRF SYSTEM COMMISSIONING

A. General

1. The VRF Manufacturer shall oversee and assist the installing contractor with the start up and commissioning of VRF equipment as outlined below. This process will be completed in two phases. Phase one shall cover the Pre-Start-Up inspection process, Phase two will cover the Physical Start-Up & Commissioning of Equipment.
2. All *VRF System Commissioning* activities shall be completed by an employee of the VRF manufacturer whose primary job responsibilities are to provide start up and commissioning of their products; sales staff or in-house support staffs are not permitted to complete this scope of work.
3. A factory certified representative may assist the VRF manufacturer's personnel in the completion of certain elements of work contained within this specification. Activities completed by a Factory Certified Representative shall be supervised onsite by the VRF manufacturer. Certified representatives shall not be used in lieu of the manufacturer's personnel.
4. The installing contractor shall have been certified by the manufacturer to install VRF systems, having attended a minimum 3- day VRF Service & Installation course at an approved training center. A copy of this certificate shall be presented as part of the VRF equipment submittal process
5. The installing contractor shall assist the VRF manufacturer in their completion of the system review and have available a technician with appropriate diagnostic tools, materials and equipment, as required, for the duration of the inspection process. The technician shall be fully licensed and insured to complete necessary duties as directed under the supervision of the VRF manufacturer.
6. Upon completion of the Equipment Start-Up & VRF Commissioning process, the VRF manufacturer shall provide a formal report outlining the status of the system, in electronic format only. Contained within this report shall be copies of all field inspection reports, required action items and status, Manufacturers design software As-Built, equipment model & serial numbers.
7. Completion of the Equipment Start-Up and VRF Commissioning process shall verify that the VRF system has been installed per the Engineer's design intent and complies with the VRF manufacturers engineering and installation specifications related to their equipment.
8. Compliance with federal, state and local codes as well as other authorities having jurisdictions are not part of this process and are the responsibility of the installing contractor.

B. Pre-Start-Up Inspection

1. Contractor shall employ the services of the VRF manufacturer to provide a comprehensive field review of the completed VRF system installation, prior to the physical start up and operation of equipment. Upon satisfaction that the system meets the VRF manufacturer's installation requirements and specifications, the contractor shall be allowed to proceed with the physical start up and operation of equipment.
2. Prior to the pre-start-up inspection, all systems components shall be in a final state of readiness having been fully installed and awaiting inspection.
3. The installing contractor shall provide the VRF manufacturer a copy of the electronic design file used in the design and engineering process of the system being inspected. This electronic design file shall have been completed on software approved by the specified VRF manufacturer and shall have been updated to reflect as-built conditions.

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4. The installing contractor shall have prepared the refrigeration piping systems per equipment installation and service manuals. All refrigerant piping systems, upon completion of assembly, shall have been pressurized to a minimum 600 PSI, using dry nitrogen, and held for an uninterrupted 24HR period, with acceptable change due to atmospheric conditions.
 - a. A record of the pressure check process shall be recorded and tagged at the outdoor unit. The tag shall contain the following information: date & time of pressure check start, fill pressure, outdoor temperature at start & stop, date & time of pressure check completion, and the person's full name & company information completing the pressure check.
 - b. The installing contractor shall engage the General Contractor as a witness of the pressure check process, confirming that all steps and procedures related to the pressure check were properly followed and that the system held the holding pressure of 600PSI for a period of 24hr hours, with acceptable change due to atmospheric conditions. Witness information, including full name, company name, title, phone number and signature shall be recorded on same pressure tag used by installing contractor.
5. Upon completion of the 600 PSI pressure check, the system shall be evacuated to a level of 500 microns, where it will be held for a period of 1HR with no deflection. The installing contractor shall utilize the triple evacuation method per the equipment install and service manuals.
 - a. Evacuation start & stop dates, times, and persons involved shall be recorded and tagged at the outdoor equipment.
 - b. Installing contractor shall digitally capture a photo of the micron gauge reading, at the conclusion of the 1hr holding period, for each system and provide a copy to the VRF manufacturer. Each photo shall contain a tag providing the outdoor units Serial number.
6. Upon the completion of the 500-micron hold, the calculated additional refrigerant charge can be added. The calculated refrigerant charge shall have been calculated using the VRF manufacturers design software.
 - a. Total refrigerant charge of the system shall be recorded and displayed at the outdoor unit by permanent means.
7. A review of the equipment settings shall be completed, with recommendations provided to improve system performance, if applicable. Physical changes of system settings will be completed by the contractor. Electronic recording of final DIP switches shall be provided as part of the commissioning report.
8. A comprehensive review and visual inspection shall be completed for each piece of equipment following a detailed check list, specific to the equipment being reviewed. A copy of the inspection report shall be provided as part of the manufacturers close out documentation. Any deficiencies found during the inspection process shall be brought to the attention of the installing contractor for corrective action. Any system components that are not accessible for proper inspection shall be noted as such.
9. Indoor Equipment report shall contain
 - a. Model & Serial Number
 - b. Equipment location
 - c. Equipment Tag/Identification number
 - d. Network Address & Port Assignment
 - e. Digital recording of equipment settings
 - f. Mounting/support method

- g. Proper service clearance provided
- h. Wiring and connection points are correct
- i. High voltage reading(s) within acceptable range
- j. Low voltage reading(s) within acceptable range
- k. Type of Remote Controller used and its location
- l. Occupied space temperature sensing location
- m. Air temperature readings within acceptable range
- n. Condensate pump interlock method
- o. Fan E.S.P. setting
- p. Air Filter condition
- q. Height differential setting in heat mode
- r. Noise level acceptable
- s. Refrigerant pipe connected and insulated properly
- t. Condensate pipe connected and insulated properly
- u. Condition of connected ductwork
- v. Review of air balance report complete
- w. Other interlocked systems, i.e. baseboard heat, booster fan etc.

C. Physical Startup and Commissioning

- 1. Upon proper equipment start up by the contractor, following the manufacturers guidelines and specifications, an employee of the VRF manufacturer shall complete a review of the system performance and complete the following tasks:
 - 2. Check and confirm all communication addressing of system components.
 - 3. Check and confirm each indoor unit, individually, is properly piped and wired by commanding the indoor unit on, in either heat or cool mode and verifying proper response.
 - a. This process shall be digitally recorded and included as part of the close out documentation.
 - 4. Electronically record a minimum of one-hour of operational data per refrigeration system.
 - 5. Electronically record selector switch positions on all indoor and outdoor equipment.
 - 6. The VRF manufacturer shall retain the electronically recorded data, collected during the start-up and equipment commissioning process, at a designated location within the US for future reference.

D. Closeout Information

- 1. The VRF manufacturer shall issue a System Performance report at the completion of all fieldwork. Contained within this report shall be an overview of the system performance, recommendations, field reports, all electronic data, and as-built design file.

3.6 DEMONSTRATION

- A. The VRF manufacturer shall provide the owner's representative a minimum 8-hour VRF Operation and Maintenance training class covering systems installed under this scope of work.
- B. Training program is to be provided at the time of owner occupancy.
- C. Owner shall provide a suitable location, onsite, to conduct the VRF Operation and Maintenance class.

- D. Training material shall be provided to participants in electronic format.

3.7 SERVICE

- A. Provide preventative maintenance as indicated above.

END OF SECTION 238129

SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Building wires and cables rated 600 V and less.
2. Connectors, splices, and terminations rated 600 V and less.

B. Related Requirements:

1. Section 260523 "Control-Voltage Electrical Power Cables" for control systems communications cables and Classes 1, 2 and 3 control cables.

1.3 ACTION SUBMITTALS

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

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

- 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. Cerro Wire LLC.
2. General Cable; General Cable Corporation.
3. Southwire Company.
4. Encore Wiring Corporation.

- B. Copper Conductors: Comply with NEMA WC 70/ICEA S-95-658.

- C. Conductor Insulation: Comply with NEMA WC 70/ICEA S-95-658 Type THHN-2-THWN-2.

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- D. Multiconductor Cable: Comply with NEMA WC 70/ICEA S-95-658 for metal-clad cable, Type MC with ground wire.

2.2 CONNECTORS AND SPLICES

- 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. 3M.
 - 2. Hubbell Power Systems, Inc.
 - 3. ILSCO.
 - 4. 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 SYSTEM DESCRIPTION

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

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

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

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

- A. Service Entrance: Type THHN-2-THWN-2, single conductors in raceway.
- B. Exposed Feeders: Type THHN-2-THWN-2, single conductors in raceway.
- C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspace: Type THHN-2-THWN-2, single conductors in raceway.
- D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-2-THWN-2, single conductors in raceway.
- E. Exposed Branch Circuits, Including in Crawlspace: Type THHN-2-THWN-2, single conductors in raceway.

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- F. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-2-THWN-2, single conductors in raceway.
- G. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-2-THWN-2, single conductors in raceway.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

- A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.
- B. Complete raceway installation between conductor and cable termination points according to Section 260533 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.
- C. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
- D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
- E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.
- F. Branch Circuits Concealed in Casework: MC cable may be used to feed to outlet boxes fish concealed in built-in casework. Route cable supported tight in upper inside corners of casework, not in conflict with drawers or cabinet doors.
- G. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."
- H. Complete cable tray systems installation according to Section 260536 "Cable Trays for Electrical Systems" prior to installing conductors and cables.
- I. Whips from Junction Box Concealed in Ceilings to Lighting Fixtures:
 - 1. Type MC Cable or FMC, with minimum #12AWG copper THHN/THWN and full size equipment grounding conductor. Maximum length 72".
 - 2. MC Cable and FMC shall be supported within 24" of fixture connection so that whip is not in contact with ceiling or grid. Securing to fixture support wires with batwings is acceptable but not to ceiling support wires.
 - 3. Do not connect fixture whips from fixture to fixture (daisy chain). No more than 4 whips shall be connected to any one junction box.
- J. All single-phase circuits shall include a dedicated neutral (grounded) and grounding conductor, unless specifically noted otherwise.
 - 1. The intent of this is to eliminate multiwire branch circuits and allow disconnection of one circuit without requiring disconnection of other(s) as would be required to comply with NEC 210.4(B). Per NEC 310.15(B)(b) each of these neutral (grounded) conductor is not considered to be load-bearing so derating is not required.

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- K. Contract drawings are based upon a maximum of 3 current-carrying conductors in a conduit. Contractor may rework indicated circuitry to install a maximum of (6) L-N circuits (120 or 277V) in a single conduit. There shall be no more than 2 each A, B, C phase conductors per homerun. Each shall have dedicated neutral (grounded) conductor.
 - 1. Do not group L-L circuits in a homerun, unless specifically indicated on the drawings.
 - 2. Where there are more than 3 current-carrying conductors in a conduit, de-rate conductor ampacities in accordance with NEC Table 310.15(B)(2)(a).
 - 3. When running more than 3 ungrounded conductors in a raceway, increase size of conduits beyond those indicated in contract documents, as required to not exceed NEC Chapter 9, Table 1 conduit-fill requirements. As-built drawings shall clearly indicate which circuits are grouped in homeruns.

- L. Unless otherwise indicated, minimum conductor size shall be 12 AWG.

3.4 CONNECTIONS

- A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

- B. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than un-spliced conductors.
 - 1. Use oxide inhibitor in each splice, termination, and tap for aluminum conductors.

- C. Wiring at Outlets: Install conductor at each outlet, with at least 12 inches of slack.

3.5 IDENTIFICATION

- A. Identify and color-code conductors and cables according to Section 260553 "Identification for Electrical Systems."

- B. Identify each spare conductor at each end with identity number and location of other end of conductor and identify as spare conductor.

3.6 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

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

3.7 FIRESTOPPING

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

3.8 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Perform the following tests and inspections:
 - 1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors for compliance with requirements.
 - 2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
- C. Test and Inspection Reports: Prepare a written report to record the following:
 - 1. Procedures used.
 - 2. Results that comply with requirements.
 - 3. Results that do not comply with requirements and corrective action taken to achieve compliance with requirements.
- D. Cables will be considered defective if they do not pass tests and inspections.

END OF SECTION 260519

SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes grounding and bonding systems and equipment, plus the following special applications:
 - 1. Underground distribution grounding.
 - 2. Foundation steel electrodes.

1.3 ACTION SUBMITTALS

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

1.4 INFORMATIONAL SUBMITTALS

- A. As-Built Data: Plans showing dimensioned as-built locations of grounding features specified in "Field Quality Control" Article, including the following:
 - 1. Test wells.
 - 2. Ground rods.
 - 3. Grounding arrangements and connections for separately derived systems.
- B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals.
 - 1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - a. Instructions for periodic testing and inspection of grounding features at test wells ground rings and grounding connections for separately derived systems based on NETA MTS.

- 1) Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.
- 2) Include recommended testing intervals.

1.6 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- 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. Burndy; Part of Hubbell Electrical Systems.
 2. ERICO International Corporation.
 3. Galvan Industries, Inc.: Electrical Products Division, LLC.
 4. ILSCO.
 5. O-Z/Gedney; an EGS Electrical Group brand; an Emerson Industrial Automation business.

2.2 SYSTEM DESCRIPTION

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

2.3 CONDUCTORS

- A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.
- B. Bare Copper Conductors:
 1. Solid Conductors: ASTM B 3.
 2. Stranded Conductors: ASTM B 8.
 3. Tinned Conductors: ASTM B 33.
 4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
 5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
 6. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

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- 7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

- C. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches in cross section, with 9/32-inch holes spaced 1-1/8 inches apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V and shall be Lexan or PVC, impulse tested at 5000 V.

2.4 CONNECTORS

- A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.
- B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy.
- C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
- D. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

2.5 GROUNDING ELECTRODES

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

PART 3 - EXECUTION

3.1 APPLICATIONS

- A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.
- B. Underground Grounding Conductors: Install bare copper conductor, No. 2/0 AWG minimum.
 - 1. Bury at least 24 inches below grade.
 - 2. Ductbank Grounding Conductor: Bury 12 inches above ductbank when indicated as part of duct-bank installation.
- C. Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
 - 1. Install bus horizontally, on insulated spacers 2 inches minimum from wall, 6 inches above finished floor unless otherwise indicated.
 - 2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down; connect to horizontal bus.
- D. Conductor Terminations and Connections:

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

3.2 GROUNDING AT THE SERVICE

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

3.3 GROUNDING SEPARATELY DERIVED SYSTEMS

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

3.4 EQUIPMENT GROUNDING

- A. Install insulated equipment grounding conductors with all feeders and branch circuits.
- B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
 1. Feeders and branch circuits.
 2. Lighting circuits.
 3. Receptacle circuits.
 4. Single-phase motor and appliance branch circuits.
 5. Three-phase motor and appliance branch circuits.
 6. Flexible raceway runs.
 7. Metal-clad cable runs.
- C. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.
- D. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

3.5 INSTALLATION

- A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
- B. Ground Rods: Drive rods until tops are 2 inches below finished floor or final grade unless otherwise indicated.

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1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
 2. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.
- C. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Section 260543 "Underground Ducts and Raceways for Electrical Systems," and shall be at least 12 inches deep, with cover.
1. Test Wells: Install at least one test well for each service unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.
- D. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.
1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
 2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
 3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.
- E. Grounding and Bonding for Piping:
1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
 2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
 3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.
- F. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install bonding jumper to bond across flexible duct connections to achieve continuity.
- G. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet apart.

3.6 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.

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- B. Perform tests and inspections.
- C. Tests and Inspections:
 - 1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
 - 2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
 - 3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, at ground test wells. Make tests at ground rods before any conductors are connected.
 - a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
 - b. Perform tests by fall-of-potential method according to IEEE 81.
 - 4. Prepare dimensioned Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.
- D. Grounding system will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.
- F. Report measured ground resistances that exceed the following values:
 - 1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
 - 2. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.
 - 3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
 - 4. Power Distribution Units or Panelboards Serving Electronic Equipment: 3 ohm(s).
- G. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION 260526

SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

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. Hangers and supports for electrical equipment and systems.
 - 2. Construction requirements for concrete bases.

1.3 DEFINITIONS

- A. EMT: Electrical metallic tubing.
- B. RMC: Rigid metal conduit.

1.4 PERFORMANCE REQUIREMENTS

- A. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.
- B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
- C. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project.

1.5 ACTION SUBMITTALS

- A. Product Data: For the following:
 - 1. Steel slotted support systems.

1.6 QUALITY ASSURANCE

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

- B. Comply with NFPA 70.

1.7 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified together with concrete Specifications.
- B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Section 077200 "Roof Accessories."

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. 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. Cooper B-Line, Inc.; a division of Cooper Industries.
 - b. ERICO International Corporation.
 - c. Thomas & Betts Corporation.
 - d. Unistrut; an Atkore International company.
 - 2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
 - 3. 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.

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- 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) Hilti, Inc.
 - 2) MKT Fastening, LLC.
 - 3) Simpson Strong-Tie Co., Inc.
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. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1) Cooper B-Line, Inc.; a division of Cooper Industries.
 - 2) Hilti, Inc.
 - 3) 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 Section 055000 "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 and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch in diameter.
- C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with two-bolt conduit clamps.

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

3.2 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.

B. Raceway Support Methods: In addition to methods described in NECA 1, EMT and RMC 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.

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. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.

5. To Steel: Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69.

6. To Light Steel: Sheet metal screws.

7. 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 Section 055000 "Metal Fabrications" for site-fabricated metal supports.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

C. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 CONCRETE BASES

- A. Construct concrete bases of dimensions indicated but not less than 4 inches larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.
- B. Use 3000-psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Section 033000 "Cast-in-Place Concrete."
- C. Anchor equipment to concrete base.
 - 1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 2. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.5 PAINTING

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 - 1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.
- B. Touchup: Comply with requirements in Division 9 for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 260529

SECTION 260533 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Metal conduits, tubing, and fittings.
 - 2. Nonmetal conduits, tubing, and fittings.
 - 3. Metal wireways and auxiliary gutters.
 - 4. Boxes, enclosures, and cabinets.
 - 5. Handholes and boxes for exterior underground cabling.

1.3 DEFINITIONS

- A. GRC: Galvanized rigid steel conduit.
- B. EMT: Electrical Metallic Tubing.

1.4 ACTION SUBMITTALS

- A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.
- B. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

1.5 INFORMATIONAL SUBMITTALS

- A. Source quality-control reports.

PART 2 - PRODUCTS

2.1 METAL CONDUITS, TUBING, AND FITTINGS

- 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:

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1. Allied Tube & Conduit.
 2. O-Z/Gedney; an EGS Electrical Group brand; an Emerson Industrial Automation business.
 3. Robroy Industries.
 4. Thomas & Betts Corporation.
- B. Listing and Labeling: Metal conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. GRC: Comply with ANSI C80.1 and UL 6.
- D. EMT: Comply with ANSI C80.3 and UL 797.
- E. FMC: Comply with UL 1; zinc-coated steel.
- F. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.
- G. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.
1. Fittings for EMT:
 - a. Material: Steel.
 - b. Type: compression.
 2. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.
- H. Joint Compound for GRC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 NONMETALLIC CONDUITS, TUBING, AND FITTINGS

- 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. AFC Cable Systems, Inc.
 2. Electri-Flex Company.
 3. RACO; Hubbell.
 4. Thomas & Betts Corporation.
- B. Listing and Labeling: Nonmetallic conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.
- D. LFNC: Comply with UL 1660.
- E. Rigid HDPE: Comply with UL 651A.

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- F. RTRC: Comply with UL 1684A and NEMA TC 14.
- G. Fittings for ENT and RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.
- H. Fittings for LFNC: Comply with UL 514B.
- I. Solvent cements and adhesive primers shall have a VOC content of 510 and 550 g/L or less, respectively, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.3 METAL WIREWAYS AND AUXILIARY GUTTERS

- 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. Cooper B-Line, Inc.; a division of Cooper Industries.
 - 2. Hoffman; a brand of Pentair Equipment Protection.
 - 3. Square D.
- B. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 1 or Type 3R unless otherwise indicated, and sized according to NFPA 70.
 - 1. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
- D. Wireway Covers: Screw-cover type unless otherwise indicated.
- E. Finish: Manufacturer's standard enamel finish.

2.4 BOXES, ENCLOSURES, AND CABINETS

- 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. EGS/Appleton Electric.
 - 2. Erickson Electrical Equipment Company.
 - 3. Hoffman; a brand of Pentair Equipment Protection.
 - 4. Hubbell Incorporated.
 - 5. O-Z/Gedney; an EGS Electrical Group brand; an Emerson Industrial Automation business.
 - 6. RACO; Hubbell.
- B. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.
- C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

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- D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.
- E. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.
- F. Metal Floor Boxes:
 - 1. Material: sheet metal.
 - 2. Type: Semi-adjustable.
 - 3. Shape: Rectangular.
 - 4. Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- G. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb. Outlet boxes designed for attachment of luminaires weighing more than 50 lb shall be listed and marked for the maximum allowable weight.
- H. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- I. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, galvanized, cast iron with gasketed cover.
- J. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
- K. Device Box Dimensions: 4 inches square by 2-1/8 inches deep.
- L. Gangable boxes are allowed.
- M. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1 or Type 3R with continuous-hinge cover with flush latch unless otherwise indicated.
 - 1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
 - 2. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.
- N. Cabinets:
 - 1. NEMA 250, Type 1 or Type 3R galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
 - 2. Hinged door in front cover with flush latch and concealed hinge.
 - 3. Key latch to match panelboards.
 - 4. Metal barriers to separate wiring of different systems and voltage.
 - 5. Accessory feet where required for freestanding equipment.

2.5 FLOOR BOXES AND SERVICE FITTINGS

- A. Basis of Design: Wiremold, RFB4 Series Floor Boxes.
 - 1. Floor boxes mounted on first floor grade shall be manufactured from cast-iron and be approved for use on grade and above grade floors. The box shall be 14 1/2" L x 11 7/8"

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W x 3 7/16" H. There shall be four independent wiring compartments that allow capacity for up to four duplex receptacles and/or communication services. The RFB4-CI-1 Series Box shall permit tunneling from adjacent or opposite compartments. Two of the four compartments shall have a minimum wiring capacity of 27 cu in., and two compartments shall have a minimum wiring capacity of 36 cu in.. The box shall provide the following number of conduit hubs: four 1" and four 1 1/4". The box shall be fully adjustable, providing a maximum of 1 7/8" pre-pour adjustment, and a maximum of 3/4" after-pour adjustment. Wiremold RFB4-CI-1.

2. Floor boxes not on grade slab shall be manufactured from stamped-steel and be approved for use on above-grade floors. The box shall be 13 5/8" L x 10" W x 2 7/16" H. There shall be four independent wiring compartments that allow capacity for up to four duplex receptacles and/or communication services. The RFB4-SS Series Box shall permit feed through tunneling from adjacent compartments. Two of the four compartments shall have a minimum wiring capacity of 15.7 cu in., and two compartments shall have a minimum wiring capacity of 31.2 cu in.. The box shall provide the following number of conduit knockouts: two 1/2", six 3/4", and eight 1". The box shall be fully adjustable, providing a maximum of 1 7/8" pre-pour adjustment, and a maximum of 3/4" after-pour adjustment. Wiremold RFB4-SS.
3. Activation covers shall be manufactured of die-cast aluminum or die-cast zinc, and shall have a plated brass finish. The activation cover shall be listed by UL to meet the applicable U.S. and Canadian safety standards for scrub water exclusion when used on tile, terrazzo, wood, and carpet covered floors. The floor box manufacturer shall provide a complete line of faceplates and bezels to facilitate mounting of UTP, STP (150 ohm), fiber optic, coaxial, and communication devices within the box.
4. Activation covers shall be available in flanged and flangeless versions of cast aluminum with aluminum, black, bronze, brass, nickel or gray finish. Covers shall be available with options for tile or carpet inserts, flush covers, or furniture feed. Flanged covers shall be 7 3/4" L x 6 9/16" W. Flangeless covers shall be 6 3/4" L x 5 9/16" W.
 - a. Unless indicated otherwise, provide the following cover configurations:
 - 1) Power/Telecom Outlets: Brushed aluminum flanged with blank lid flush with floor and NO carpet/tile cutouts.
 - 2) Furniture Floor Feed: Brushed aluminum flanged with 1" trade size screw plug opening and one combination 1 1/4" and 2" trade size screw plug openings.

B. Basis of Design: Wiremold, Omnibox Floor Boxes, One-, two- or three-gang floor boxes.

1. Floor boxes mounted on first floor grade shall be manufactured from cast-iron and be approved for use on grade and above grade floors. Box interior and exterior shall be painted. Boxes shall be available in one-, two-, and three-gang configurations. Gymnasium floor boxes shall be suitable for wood floors. All cast-iron versions shall provide 1 3/4" of pre-pour adjustment and 1/2" of post-pour adjustment. Minimum depth of deep boxes shall be 3 7/16". Overall box dimensions shall be as follows:
 - a. One-gang: 5 3/16" W x 4 3/8" L
 - b. Two-gang: 5 3/16" W x 8 1/2" L
 - c. Three-gang: 5 3/16" W x 12 1/2" L

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2. Floor boxes on the second floor and above shall be manufactured from stamped-steel and be approved for use on cast-in-place floors. Boxes shall be manufactured from stamped steel and formed. Boxes shall be available in one-, two-, or three-gang configurations. All stamped steel versions shall provide 1 3/4" of pre-pour adjustment and 1/2" of post-pour adjustment. Maximum depth of boxes shall be 2 15/32". Overall box dimensions shall be as follows:
 - a. One-gang: 4 13/16" W x 3 23/32" L
 - b. Two-gang: 4 13/16" W x 7 15/16" L
 - c. Three-gang: 4 13/16" W x 12" L

3. All floor box options shall accept brass cover plates and flanges. Flanges for brass, shall be available for one-, two-, or three-gang applications and install on the previously mentioned boxes. Each flange shall provide 1/2" of adjustment to accommodate various floor covering and concrete pour depths.
 - a. All brass flanges shall be approved for use on carpet, tile, or wood covered floor applications. Brass and brushed aluminum flanges and cover plates shall have a buffed appearance and be protected with a lacquer finish. Nonmetallic flanges and cover plates shall be provided in a black, brown, or gray finish. Modular inserts shall snap directly into each flange through use of a mounting bezel.
 - b. Brushed aluminum and nonmetallic cover plate options shall seat inside either the aluminum or nonmetallic flanges and be flush with the finished floor. Brushed aluminum and nonmetallic cover plate dimensions shall be 3.29" W x 4.310" L. Brass cover plate dimensions are 3.156" W x 4.182" L. Brass cover plates shall seat inside only brass flanges and be flush with the finished floor. All cover plate options shall provide for both power and communication services.

2.6 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

A. General Requirements for Handholes and Boxes:

1. Boxes and handholes for use in underground systems shall be designed and identified as defined in NFPA 70, for intended location and application.
2. Boxes installed in wet areas shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. All exterior handholes shall be traffic rated.

B. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel, fiberglass, or a combination of the two.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Armorcast Products Company.
 - b. Carson Industries LLC.
 - c. Quazite: Hubbell Power Systems, Inc.

2. Standard: Comply with SCTE 77.
3. Configuration: Designed for flush burial with open bottom unless otherwise indicated.

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4. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
5. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
6. Cover Legend: Molded lettering, "**ELECTRIC.**".
7. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
8. Handholes 12 Inches Wide by 24 Inches Long and Larger: Have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.7 SOURCE QUALITY CONTROL FOR UNDERGROUND ENCLOSURES

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

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

- A. Outdoors: Apply raceway products as specified below unless otherwise indicated:
 1. Exposed Conduit: GRC.
 2. Concealed Conduit, Aboveground: GRC.
 3. Underground Conduit: RNC, Type EPC-40-PVC, direct buried.
 4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
 5. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.
- B. Indoors: Apply raceway products as specified below unless otherwise indicated:
 1. Exposed, Not Subject to Physical Damage: EMT.
 2. Exposed, Not Subject to Severe Physical Damage: EMT.
 3. Exposed and Subject to Severe Physical Damage: GRC. Raceway locations include the following:
 - a. Loading dock.
 - b. Mechanical rooms.
 4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
 5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.

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- 6. Damp or Wet Locations: GRC.
 - 7. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 nonmetallic in institutional and commercial kitchens and damp or wet locations.
- C. Minimum Raceway Size: 3/4-inch trade size.
- D. Raceway Fittings: Compatible with raceways and suitable for use and location.
- 1. Rigid Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
 - 2. EMT: Use compression, steel fittings. Comply with NEMA FB 2.10.
 - 3. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.
- E. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.
- F. Install surface raceways only where indicated on Drawings.
- G. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F.

3.2 INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.
- B. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
- C. Complete raceway installation before starting conductor installation.
- D. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.
- E. Arrange stub-ups so curved portions of bends are not visible above finished slab.
- F. Install no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within 12 inches of changes in direction.
- G. Conceal conduit and EMT within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
- H. All conduit to be installed on exterior masonry shall not run continuously within the wall cavity.
- I. Support conduit within 12 inches of enclosures to which attached.
- J. Raceways Embedded in Slabs:
 - 1. Are not permitted, except as required for entry into recessed floor boxes.

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2. Conduits run below slab on ground floor level shall be buried within the porous fill and stub-up at the required location. Transition from RNC to RGS with RGS elbow before rising above the floor. After RGS elbow, stub-up conduit shall be type indicated in Part 3.1 above.
 3. Where raceways are terminated with threaded hubs, screw raceways or fittings tightly into hub so end bears against wire protection shoulder. Where chase nipples are used, align raceways so coupling is square to box; tighten chase nipple so no threads are exposed.
 4. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.
 5. Change from ENT to GRC before rising above floor.
- K. Stub-ups to Above Recessed Ceilings:
1. Use EMT or RMC for raceways.
 2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.
- L. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.
- M. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors including conductors smaller than No. 4 AWG.
- N. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch trade size and insulated throat metal bushings on 1-1/2-inch trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.
- O. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.
- P. 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.
- Q. Cut conduit perpendicular to the length. For conduits 2-inch trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.
- R. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.
- S. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings according to NFPA 70.
- T. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:

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1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
 2. Where an underground service raceway enters a building or structure.
 3. Where otherwise required by NFPA 70.
- U. Comply with manufacturer's written instructions for solvent welding RNC and fittings.
- V. Expansion-Joint Fittings:
1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F and that has straight-run length that exceeds 25 feet. Install in each run of aboveground RMC and EMT conduit that is located where environmental temperature change may exceed 100 deg F and that has straight-run length that exceeds 100 feet.
 2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:
 - a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.
 - b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
 - c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F temperature change.
 - d. Attics: 135 deg F temperature change.
 3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F of temperature change for metal conduits.
 4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
 5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.
- W. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72 inches of flexible conduit for recessed and semi-recessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
1. Use LFMC in damp or wet locations subject to severe physical damage.
 2. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.
- X. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements and also refer to Architectural elevations. Install boxes with height measured to center of box unless otherwise indicated.
- Y. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.
- Z. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.

- AA. Locate boxes so that cover or plate will not span different building finishes.
- BB. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.
- CC. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.
- DD. Set metal floor boxes level and flush with finished floor surface.

3.3 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:

1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Section 312000 "Earth Moving" for pipe less than 6 inches in nominal diameter.
2. Install backfill as specified in Section 312000 "Earth Moving."
3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Section 312000 "Earth Moving."
4. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through floor.
 - a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete for a minimum of 12 inches on each side of the coupling.
 - b. For stub-ups at equipment mounted on outdoor concrete bases and where conduits penetrate building foundations, extend steel conduit horizontally a minimum of 60 inches from edge of foundation or equipment base. Install insulated grounding bushings on terminations at equipment.
5. Underground Warning Tape: Comply with requirements in Section 260553 "Identification for Electrical Systems."

3.4 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

- A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.
- B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
- C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch above finished grade.
- D. Install handholes with bottom below frost line, below grade.

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- E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables but short enough to preserve adequate working clearances in enclosure.
- F. Field-cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

3.5 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

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

3.6 FIRESTOPPING

- A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Division 07.

3.7 PROTECTION

- A. Protect coatings, finishes, and cabinets from damage and deterioration.
 - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
 - 2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 260533

SECTION 260543 - UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

1. Direct-buried conduit, ducts, and duct accessories.
2. Concrete-encased conduit, ducts, and duct accessories.
3. Handholes and boxes.

1.3 DEFINITIONS

- A. Trafficways: Locations where vehicular or pedestrian traffic is a normal course of events.

1.4 ACTION SUBMITTALS

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

1. Include ductbank materials, including separators and miscellaneous components.
2. Include ducts and conduits and their accessories, including elbows, end bells, bends, fittings, and solvent cement.
3. Include accessories for manholes, handholes, boxes.
4. Include warning tape.

- B. Shop Drawings:

1. Factory-Fabricated Handholes and Boxes Other Than Precast Concrete:
 - a. Include dimensioned plans, sections, and elevations, and fabrication and installation details.
 - b. Include duct entry provisions, including locations and duct sizes.
 - c. Include cover design.
 - d. Include grounding details.
 - e. Include dimensioned locations of cable rack inserts, and pulling-in and lifting irons.

1.5 INFORMATIONAL SUBMITTALS

- A. Ductbank Coordination Drawings: Show duct profiles and coordination with other utilities and underground structures.
 - 1. Include plans and sections, drawn to scale, and show bends and locations of expansion fittings.
 - 2. Drawings shall be signed and sealed by a qualified professional engineer.
- B. Field quality-control reports.

1.6 FIELD CONDITIONS

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

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR DUCTS AND RACEWAYS

- A. Comply with ANSI C2.
- B. Install underground conduits and ductbanks per the table below. Locate a minimum of 3 feet from other utility systems (steam, chilled water, sewer, storm, etc.).
 - 1. Install not less than 4- #4 reinforcing bars tied to a square cage at 8' centers for conduits in ductbank under roadways.
 - 2. Concrete encased with a minimum envelope of 3" around each conduit *where encasement is required*.
 - 3. Concrete shall be red dyed utilizing red dye mixed into the concrete for a minimum of 5 minutes prior to pouring. Minimum of 1 bag of dye per 1 yard of concrete.
 - 4. Fire pump feeders shall be concrete encased PVC-Sched 40 below grade.

	Above 600V	600V and Below	Other Systems
Below Building Slabs	PVC-Sched 40 or GRS, 36" deep, red concrete encasement, 3000 psi	PVC-Sched 40 or GRS, 18" deep, no concrete encasement required	PVC-Sched 40 or GRS, 24" deep, no concrete encasement required

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Outside of Building Foot-print	PVC or GRS, 36" deep, red concrete encasement, 3000 psi	GRS, 36" deep, no encasement, or PVC, 24" deep with 2000 psi concrete encasement, no dye	GRS, 36" deep, no encasement, or PVC, 24" deep with 2000 psi concrete encasement, no dye (PVC-Sch 80 below auto traffic areas)
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2.2 CONDUIT

- A. Rigid Steel Conduit: Galvanized. Comply with ANSI C80.1.
- B. RNC: NEMA TC 2, Type EPC-40-PVC and Type EPC-80-PVC, UL 651, with matching fittings by same manufacturer as the conduit, complying with NEMA TC 3 and UL 514B.

2.3 NONMETALLIC DUCTS AND DUCT ACCESSORIES

- 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. ARNCO Corp.
 - 2. Electri-Flex Company.
 - 3. Lamson & Sessions.
 - 4. Spiraduct/AFC Cable Systems, Inc.
- B. Underground Plastic Utilities Duct: NEMA TC 2, UL 651, ASTM F 512, Type EPC-80 and Type EPC-40, with matching fittings complying with NEMA TC 3 by same manufacturer as the duct.
- C. Underground Plastic Utilities Duct: NEMA TC 6 & 8, ASTM F 512, UL 651A, Type HDPE and Type EB-20-PVC, with matching fittings complying with NEMA TC 9 by same manufacturer as the duct.
- D. Underground Plastic Utilities Duct: NEMA TC 6 & 8, ASTM F 512, Type DB-60-PVC and Type DB-120-PVC, for direct burial, with matching fittings complying with NEMA TC 9 by same manufacturer as the duct.
- E. Duct Accessories:
 - 1. Duct Separators: Factory-fabricated rigid PVC interlocking spacers, sized for type and size of ducts with which used, and selected to provide minimum duct spacing indicated while supporting ducts during concreting or backfilling.
 - 2. Warning Tape: Underground-line warning tape specified in Section 260553 "Identification for Electrical Systems."

2.4 PRECAST CONCRETE HANDHOLES AND BOXES

- 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. Christy Concrete Products.
 2. Oldcastle Precast, Inc.
 3. Utility Concrete Products, LLC.
- B. Comply with ASTM C 858 for design and manufacturing processes.
- C. Description: Factory-fabricated, reinforced-concrete, monolithically poured walls and bottom unless open-bottom enclosures are indicated. Frame and cover shall form top of enclosure and shall have load rating consistent with that of handhole or box.
1. Frame and Cover: Weatherproof cast-iron frame, with cast-iron cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.
 2. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
 3. Cover Legend: Molded lettering, "ELECTRIC."
 4. Configuration: Units shall be designed for flush burial and have open bottom unless otherwise indicated.
 5. Extensions and Slabs: Designed to mate with bottom of enclosure. Same material as enclosure.
 - a. Extension shall provide increased depth of 12 inches.
 - b. Slab: Same dimensions as bottom of enclosure, and arranged to provide closure.
 6. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.
 7. Windows: Precast openings in walls, arranged to match dimensions and elevations of approaching ducts and duct banks, plus an additional 12 inches vertically and horizontally to accommodate alignment variations.
 - a. Windows shall be located no less than 6 inches from interior surfaces of walls, floors, or frames and covers of handholes, but close enough to corners to facilitate racking of cables on walls.
 - b. Window opening shall have cast-in-place, welded-wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct banks.
 - c. Window openings shall be framed with at least two additional No. 3 steel reinforcing bars in concrete around each opening.
 8. Duct Entrances in Handhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.
 - a. Type and size shall match fittings to duct or conduit to be terminated.
 - b. Fittings shall align with elevations of approaching ducts and be located near interior corners of handholes to facilitate racking of cable.

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

2.5 HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

- A. General Requirements for Handholes and Boxes: Comply with SCTE 77. Comply with tier requirements in "Underground Enclosure Application" Article.
 1. Color: As directed by the architect.
 2. Configuration: Units shall be designed for flush burial and have open bottom unless otherwise indicated.
 3. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
 4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
 5. Cover Legend: Molded lettering, "ELECTRIC."
 6. Direct-Buried Wiring Entrance Provisions: Knockouts equipped with insulated bushings or end-bell fittings, selected to suit box material, sized for wiring indicated, and arranged for secure, fixed installation in enclosure wall.
 7. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
 8. Handholes 12 inches wide by 24 inches long and larger shall have factory-installed inserts for cable racks and pulling-in irons.
- B. Polymer Concrete Handholes and Boxes with Polymer Concrete Cover: Molded of sand and aggregate, bound together with a polymer resin, and reinforced with steel or fiberglass or a combination of the two.
 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. Armorcast Products Company.
 - b. Carson Industries LLC.
 - c. Quazite: Hubbell Power Systems, Inc.
- C. Fiberglass Handholes and Boxes with Polymer Concrete Frame and Cover: Sheet-molded, fiberglass-reinforced, polyester resin enclosure joined to polymer concrete top ring or frame.
 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. Armorcast Products Company.
 - b. Carson Industries LLC.
 - c. Quazite: Hubbell Power Systems, Inc.
 - d. Synertech Moulded Products.

- D. Fiberglass Handholes and Boxes: Molded of fiberglass-reinforced polyester resin, with covers made of polymer concrete.
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. Carson Industries LLC.
 - b. Christy Concrete Products.
 - c. Nordic Fiberglass, Inc.
 - d. Quazite: Hubbell Power Systems, Inc.
- E. High-Density Plastic Boxes: Injection molded of high-density polyethylene or copolymer-polypropylene. Cover shall be made of polymer concrete.
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. Carson Industries LLC.
 - b. Nordic Fiberglass, Inc.
 - c. Quazite: Hubbell Power Systems, Inc.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Coordinate layout and installation of ducts, manholes, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field. Notify Architect if there is a conflict between areas of excavation and existing structures or archaeological sites to remain.
- B. Coordinate elevations of ducts and duct-bank entrances into manholes, handholes, and boxes with final locations and profiles of ducts and duct banks, as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations as required to suit field conditions and to ensure that duct runs drain to manholes and handholes, and as approved by Architect.
- C. Clear and grub vegetation to be removed, and protect vegetation to remain according to Section 311000 "Site Clearing." Remove and stockpile topsoil for reapplication according to Section 311000 "Site Clearing."

3.2 UNDERGROUND DUCT APPLICATION

- A. Ducts for Electrical Cables More than 600 V: RNC, NEMA Type EPC-80-PVC, in concrete-encased duct bank unless otherwise indicated.

- B. Ducts for Electrical Feeders 600 V and Less: RNC, NEMA Type EPC-80 Type EPC-40-PVC, in concrete-encased duct bank unless otherwise indicated.
- C. Ducts for Electrical Feeders 600 V and Less: RNC, NEMA Type EPC-80-PVC, in direct-buried duct bank unless otherwise indicated.
- D. Ducts for Electrical Branch Circuits: RNC, NEMA Type EPC-80-PVC, in direct-buried duct bank unless otherwise indicated.
- E. Underground Ducts Crossing Paved Paths Walks and Driveways: RNC, NEMA Type EPC-40-PVC, encased in reinforced concrete.

3.3 UNDERGROUND ENCLOSURE APPLICATION

- A. Handholes and Boxes for 600 V and Less:
 - 1. Units in Roadways and Other Deliberate Traffic Paths: Precast concrete, AASHTO HB 17, H-10 structural load rating.
 - 2. Units in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: Precast concrete, AASHTO HB 17, H-20 structural load rating.
 - 3. Units in Sidewalk and Similar Applications with a Safety Factor for Nondeliberate Loading by Vehicles: Precast concrete, AASHTO HB 17, H-10 structural load rating.
 - 4. Units Subject to Light-Duty Pedestrian Traffic Only: Fiberglass-reinforced polyester resin, structurally tested according to SCTE 77 with 3000-lbf vertical loading.
 - 5. Cover design load shall not exceed the design load of the handhole or box.

3.4 EARTHWORK

- A. Excavation and Backfill: Comply with Section 312000 "Earth Moving," but do not use heavy-duty, hydraulic-operated, compaction equipment.
- B. Restore surface features at areas disturbed by excavation, and re-establish original grades unless otherwise indicated. Replace removed sod immediately after backfilling is completed.
- C. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Comply with Section 329200 "Turf and Grasses" and Section 329300 "Plants."
- D. Cut and patch existing pavement in the path of underground ducts and utility structures according to the "Cutting and Patching" Article in Section 017300 "Execution."

3.5 DUCT INSTALLATION

- A. Install ducts according to NEMA TCB 2.

- B. Slope: Pitch ducts a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope ducts from a high point in runs between two manholes, to drain in both directions.
- C. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius of 48 inches, both horizontally and vertically, at other locations unless otherwise indicated.
- D. Joints: Use solvent-cemented joints in ducts and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent ducts do not lie in same plane.
- E. Installation Adjacent to High-Temperature Steam Lines: Where duct banks are installed parallel to underground steam lines, perform calculations showing the duct bank will not be subject to environmental temperatures above 40 deg C. Where environmental temperatures are calculated to rise above 40 deg C, and anywhere the duct bank crosses above an underground steam line, install insulation blankets listed for direct burial to isolate the duct bank from the steam line.
- F. Duct Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately 10 inches o.c. for 5-inch ducts, and vary proportionately for other duct sizes.
 - 1. Begin change from regular spacing to end-bell spacing 10 feet from the end bell without reducing duct line slope and without forming a trap in the line.
 - 2. Direct-Buried Duct Banks: Install an expansion and deflection fitting in each conduit in the area of disturbed earth adjacent to manhole or handhole. Install an expansion fitting near the center of all straight line direct-buried duct banks with calculated expansion of more than 3/4 inch.
 - 3. Grout end bells into structure walls from both sides to provide watertight entrances.
- G. Building Wall Penetrations: Make a transition from underground duct to rigid steel conduit at least 10 feet outside the building wall, without reducing duct line slope away from the building, and without forming a trap in the line. Use fittings manufactured for duct-to-conduit transition. Install conduit penetrations of building walls as specified in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."
- H. Sealing: Provide temporary closure at terminations of ducts that have cables pulled. Seal spare ducts at terminations. Use sealing compound and plugs to withstand at least 15-psig hydrostatic pressure.
- I. Pulling Cord: Install 100-lbf-test nylon cord in empty ducts.
- J. Concrete-Encased Ducts: Support ducts on duct separators.
 - 1. Excavate trench bottom to provide firm and uniform support for duct bank. Prepare trench bottoms as specified in Section 312000 "Earth Moving" for pipes less than 6 inches in nominal diameter.
 - 2. Width: Excavate trench 12 inches wider than duct bank on each side.

3. Depth: Install top of duct bank at least 24 inches below finished grade in areas not subject to deliberate traffic, and at least 30 inches below finished grade in deliberate traffic paths for vehicles unless otherwise indicated.
4. Support ducts on duct separators coordinated with duct size, duct spacing, and outdoor temperature.
5. Separator Installation: Space separators close enough to prevent sagging and deforming of ducts, with not less than four spacers per 20 feet of duct. Secure separators to earth and to ducts to prevent floating during concreting. Stagger separators approximately 6 inches between tiers. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
6. Minimum Space between Ducts: 3 inches between ducts and exterior envelope wall, 2 inches between ducts for like services, and 4 inches between power and signal ducts.
7. Elbows: Use manufactured rigid steel conduit elbows for stub-ups at poles and equipment, at building entrances through floor, and at changes of direction in duct run.
 - a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete.
 - b. Stub-Ups to Equipment: For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches from edge of base. Install insulated grounding bushings on terminations at equipment.
8. Reinforcement: Reinforce concrete-encased duct banks where they cross disturbed earth and where indicated. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.
9. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.
10. Concrete Cover: Install a minimum of 3 inches of concrete cover at top and bottom, and a minimum of 2 inches on each side of duct bank.
11. Concreting Sequence: Pour each run of envelope between manholes or other terminations in one continuous operation.
 - a. Start at one end and finish at the other, allowing for expansion and contraction of ducts as their temperature changes during and after the pour. Use expansion fittings installed according to manufacturer's written recommendations, or use other specific measures to prevent expansion-contraction damage.
 - b. If more than one pour is necessary, terminate each pour in a vertical plane and install 3/4-inch reinforcing-rod dowels extending a minimum of 18 inches into concrete on both sides of joint near corners of envelope.
12. Pouring Concrete: Comply with requirements in "Concrete Placement" Article in Section 033000 "Cast-in-Place Concrete." Place concrete carefully during pours to prevent voids under and between conduits and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Allow concrete to flow to center of bank and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-bank application.

K. Direct-Buried Duct Banks:

1. Excavate trench bottom to provide firm and uniform support for duct bank. Comply with requirements in Section 312000 "Earth Moving" for preparation of trench bottoms for pipes less than 6 inches in nominal diameter.
 2. Support ducts on duct separators coordinated with duct size, duct spacing, and outdoor temperature.
 3. Space separators close enough to prevent sagging and deforming of ducts, with not less than four spacers per 20 feet of duct. Secure separators to earth and to ducts to prevent displacement during backfill and yet permit linear duct movement due to expansion and contraction as temperature changes. Stagger spacers approximately 6 inches between tiers.
 4. Depth: Install top of ductbank at least 36 inches below finished grade unless otherwise indicated.
 5. Set elevation of bottom of ductbank below frost line.
 6. Install ducts with a minimum of 3 inches between ducts for like services and 6 inches between power and signal ducts.
 7. Elbows: Install manufactured duct elbows for stub-ups at poles and equipment, at building entrances through floor, and at changes of direction in duct run unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.
 8. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment, at building entrances through floor, and at changes of direction in duct run.
 - a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete.
 - b. For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.
 9. After installing first tier of ducts, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this process. Repeat procedure after placing each tier. After placing last tier, hand place backfill to 4 inches over ducts and hand tamp. Firmly tamp backfill around ducts to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct connections at end of run and complete backfilling with normal compaction. Comply with requirements in Section 312000 "Earth Moving" for installation of backfill materials.
 - a. Place minimum 3 inches of sand as a bed for duct bank. Place sand to a minimum of 6 inches above top level of duct bank.
 - b. Place minimum 6 inches of engineered fill above concrete encasement of duct bank.
- L. Warning Tape: Bury warning tape approximately 12 inches above all concrete-encased ducts and duct banks. Align tape parallel to and within 3 inches of centerline of duct bank. Provide an additional warning tape for each 12-inch increment of duct-bank width over a nominal 18 inches. Space additional tapes 12 inches apart, horizontally.

3.6 INSTALLATION OF CONCRETE MANHOLES, HANDHOLES, AND BOXES

A. Precast Concrete Handhole and Manhole Installation:

1. Comply with ASTM C 891 unless otherwise indicated.
2. Install units level and plumb and with orientation and depth coordinated with connecting ducts, to minimize bends and deflections required for proper entrances.
3. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

B. Elevations:

1. Install handholes with bottom below frost line, below grade.
2. Handhole Covers: In paved areas and trafficways, set surface flush with finished grade. Set covers of other handholes 1 inch above finished grade.
3. Where indicated, cast handhole cover frame integrally with handhole structure.

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

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

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

3.7 INSTALLATION OF HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting ducts, to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of ducts, and seal joint between box and extension as recommended by manufacturer.

B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas and trafficways, set cover flush with finished grade. Set covers of other handholes 1 inch above finished grade.

D. Install handholes and boxes with bottom below frost line, below grade.

E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in enclosure.

- F. Field cut openings for ducts and conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.
- G. For enclosures installed in asphalt paving and subject to occasional, nondeliberate, heavy-vehicle loading, form and pour a concrete ring encircling, and in contact with, enclosure and with top surface screeded to top of box cover frame. Bottom of ring shall rest on compacted earth.
 - 1. Concrete: 3000 psi, 28-day strength, complying with Section 033000 "Cast-in-Place Concrete," with a troweled finish.
 - 2. Dimensions: 10 inches wide by 12 inches deep.

3.8 GROUNDING

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

3.9 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections and prepare test reports:
 - 1. Demonstrate capability and compliance with requirements on completion of installation of underground ducts and utility structures.
 - 2. Pull solid aluminum or wood test mandrel through duct to prove joint integrity and adequate bend radii, and test for out-of-round duct. Provide a minimum 6-inch-long mandrel equal to 80 percent fill of duct. If obstructions are indicated, remove obstructions and retest.
 - 3. Test handhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Correct deficiencies and retest as specified above to demonstrate compliance.

3.10 CLEANING

- A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of ducts. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.
- B. Clean internal surfaces of manholes, including sump. Remove foreign material.

END OF SECTION 260543

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

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors.
2. Sleeve-seal systems.
3. Sleeve-seal fittings.
4. Grout.
5. Silicone sealants.

B. Related Requirements:

1. Section 078413 "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.3 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 SLEEVES

A. Wall Sleeves:

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

- B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.

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

2.2 SLEEVE-SEAL SYSTEMS

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

2.3 SLEEVE-SEAL FITTINGS

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

2.4 GROUT

- A. Description: Non-shrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.
- B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- C. Design Mix: 5000-psi, 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

2.5 SILICONE SEALANTS

- A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.
 - 1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.
 - 2. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, non-shrinking foam.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

- A. Comply with NECA 1.
- B. Comply with NEMA VE 2 for cable tray and cable penetrations.
- C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:
 - 1. Interior Penetrations of Non-Fire-Rated Walls and Floors:
 - a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 079200 "Joint Sealants."
 - b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.
 - 2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
 - 3. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed.

4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches above finished floor level. Install sleeves during erection of floors.

D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:

1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.

E. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using [steel] [cast-iron] pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing sleeve-seal system.

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

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

3.3 SLEEVE-SEAL-FITTING INSTALLATION

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

END OF SECTION 260544

SECTION 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Identification for raceways.
 - 2. Identification of power and control cables.
 - 3. Identification for conductors.
 - 4. Underground-line warning tape.
 - 5. Warning labels and signs.
 - 6. Instruction signs.
 - 7. Equipment identification labels.
 - 8. Miscellaneous identification products.

1.3 ACTION SUBMITTALS

- A. Product Data: For each electrical identification product indicated.

1.4 QUALITY ASSURANCE

- A. Comply with ANSI A13.1 and IEEE C2.
- B. Comply with NFPA 70.
- C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.
- D. Comply with ANSI Z535.4 for safety signs and labels.
- E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

1.5 COORDINATION

- A. Coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, 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.

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

PART 2 - PRODUCTS

2.1 POWER AND CONTROL RACEWAY IDENTIFICATION MATERIALS

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway size.
- B. Colors for Raceways Carrying Circuits at 600 V or Less:
 - 1. Black letters on an orange field.
 - 2. Legend: Indicate voltage and system or service type.
- C. Vinyl Labels for Raceways Carrying Circuits at 600 V or Less: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing ends of legend label.

2.2 METAL-CLAD CABLE IDENTIFICATION MATERIALS

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each cable size.
- B. Colors for Cables Carrying Circuits at 600 V and Less:
 - 1. Black letters on an orange field.
 - 2. Legend: Indicate voltage and system or service type.
- C. Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing ends of legend label.

2.3 POWER AND CONTROL CABLE IDENTIFICATION MATERIALS

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each cable size.
- B. Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing ends of legend label.

2.4 CONDUCTOR IDENTIFICATION MATERIALS

- A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inches wide.
- B. Self-Adhesive, Self-Laminating Polyester Labels: Preprinted, 3-mil- thick flexible label with acrylic pressure-sensitive adhesive that provides a clear, weather- and chemical-resistant, self-laminating, protective shield over the legend. Labels sized to fit the conductor diameter such that the clear shield overlaps the entire printed legend.

2.5 FLOOR MARKING TAPE

- A. 2-inch- wide, 5-mil pressure-sensitive vinyl tape, with yellow and black stripes and clear vinyl overlay.

2.6 UNDERGROUND-LINE WARNING TAPE

- A. Tape:
 - 1. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
 - 2. Printing on tape shall be permanent and shall not be damaged by burial operations.
 - 3. Tape material and ink shall be chemically inert, and not subject to degrading when exposed to acids, alkalis, and other destructive substances commonly found in soils.
- B. Color and Printing:
 - 1. Comply with ANSI Z535.1 through ANSI Z535.5.
 - 2. Inscriptions for Red-Colored Tapes: ELECTRIC LINE, HIGH VOLTAGE,.
 - 3. Inscriptions for Orange-Colored Tapes: TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE,.
- C. Warning Tape:
 - 1. Detectable three-layer laminate, consisting of a printed pigmented polyolefin film, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core, bright-colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
 - 2. Overall Thickness: 5 mils.
 - 3. Foil Core Thickness: 0.35 mil.
 - 4. Weight: 28 lb/1000 sq. ft..
 - 5. 3-Inch Tensile According to ASTM D 882: 70 lbf, and 4600 psi.

2.7 WARNING LABELS AND SIGNS

- A. Comply with NFPA 70 and 29 CFR 1910.145.
- B. Metal-Backed, Butyrate Warning Signs: Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch galvanized-steel backing; and with colors, legend, and

size required for application. 1/4-inch grommets in corners for mounting. Nominal size, 10 by 14 inches.

1. Warning labels and signs shall include, but are not limited to, the following:
 - a. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
 - b. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES"
 - c. Arc Flash Hazard Warning: Refer to Section 260574 for requirements.

2.8 INSTRUCTION SIGNS

- A. Engraved, laminated acrylic or melamine plastic, minimum 1/16 inch thick for signs up to 20 sq. inches and 1/8 inch thick for larger sizes.
 1. Engraved legend with black letters on white face.
 2. Punched or drilled for mechanical fasteners.
 3. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.
- B. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch.

2.9 EQUIPMENT IDENTIFICATION LABELS

- A. Engraved, Laminated Acrylic or Melamine Label: Punched or drilled for screw mounting. White letters on a dark-gray background. Minimum letter height shall be 3/8 inch.

2.10 CABLE TIES

- A. Plenum-Rated Cable Ties: Self extinguishing, UV stabilized, one piece, self locking.
 1. Minimum Width: 3/16 inch.
 2. Tensile Strength at 73 deg F, According to ASTM D 638: 7000 psi.
 3. UL 94 Flame Rating: 94V-0.
 4. Temperature Range: Minus 50 to plus 284 deg F.
 5. Color: Black.

2.11 MISCELLANEOUS IDENTIFICATION PRODUCTS

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

PART 3 - EXECUTION

3.1 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 signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
- F. System Identification Color-Coding Bands for Raceways and Cables: Each color-coding band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.
- G. Cable Ties: For attaching tags. Use general-purpose type, except as listed below:
 - 1. Outdoors: UV-stabilized nylon.
 - 2. In Spaces Handling Environmental Air: Plenum rated.
- H. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches overall.
- I. Painted Identification: Comply with requirements in painting Sections for surface preparation and paint application.

3.2 IDENTIFICATION SCHEDULE

- A. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits More Than 30 A, and 120 V to ground: Identify with self-adhesive vinyl label. Install labels at 10-foot maximum intervals.
- B. Accessible Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive vinyl labels with the wiring system legend and system voltage. System legends shall be as follows:
 - 1. Emergency Power.
 - 2. Power.
 - 3. UPS.

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- C. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use color-coding conductor tape to identify the phase.
 - 1. Color-Coding for Phase and Voltage Level Identification, 600 V or Less: Use colors listed below for ungrounded service feeder and branch-circuit conductors.
 - a. Color shall be factory applied or field applied for sizes larger than No. 8 AWG, if authorities having jurisdiction permit.
 - b. Colors for 208/120-V Circuits:
 - 1) Phase A: Black.
 - 2) Phase B: Red.
 - 3) Phase C: Blue.
 - 4) Grounded (Neutral): White.
 - 5) Ground: Green.
 - c. Colors for 480/277-V Circuits:
 - 1) Phase A: Brown.
 - 2) Phase B: Orange.
 - 3) Phase C: Yellow.
 - 4) Grounded (Neutral): Gray.
 - 5) Ground: Green.
 - d. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.
- D. Install instructional sign including the color-code for grounded and ungrounded conductors using adhesive-film-type labels.
- E. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes, manholes, and handholes, use self-adhesive, self-laminating polyester labels with the conductor or cable designation, origin, and destination.
- F. Control-Circuit Conductor Termination Identification: For identification at terminations provide heat-shrink preprinted tubes or self-adhesive, self-laminating polyester labels with the conductor designation.
- G. Conductors to Be Extended in the Future: Attach marker tape to conductors and list source.
- H. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.
 - 1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
 - 2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
 - 3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual.

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- I. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable.
 - 1. Limit use of underground-line warning tape to direct-buried cables.
 - 2. Install underground-line warning tape for both direct-buried cables and cables in raceway.

- J. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall be as required by NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

- K. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive warning labels.
 - 1. Comply with 29 CFR 1910.145.
 - 2. Identify system voltage with black letters on an orange background.
 - 3. Apply to exterior of door, cover, or other access.
 - 4. For equipment with multiple power or control sources, apply to door or cover of equipment including, but not limited to, the following:
 - a. Power transfer switches.
 - b. Controls with external control power connections.

- L. Operating Instruction Signs: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.

- M. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch- high letters for emergency instructions at equipment used for power transfer and load shedding.

- N. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and the 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. Indoor Equipment: Adhesive film label with clear protective overlay. Unless otherwise indicated, provide a single line of text with 1/2-inch- high letters on 1-1/2-inch- high label; where two lines of text are required, use labels 2 inches high.
 - b. Outdoor Equipment: Engraved, laminated acrylic or melamine label.
 - c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
 - d. Unless provided with self-adhesive means of attachment, fasten labels with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.

2. Equipment to Be Labeled:
 - a. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be, laminated acrylic or melamine label.
 - b. Enclosures and electrical cabinets.
 - c. Access doors and panels for concealed electrical items.
 - d. Switchboards.
 - e. Transformers: Label that includes tag designation shown on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.
 - f. Emergency system boxes and enclosures.
 - g. Enclosed switches.
 - h. Enclosed circuit breakers.
 - i. Enclosed controllers.
 - j. Variable-speed controllers.
 - k. Push-button stations.
 - l. Power transfer equipment.
 - m. Contactors.
 - n. Remote-controlled switches, dimmer modules, and control devices.
 - o. Power-generating units.
 - p. Monitoring and control equipment.

END OF SECTION 260553

SECTION 260574 - OVERCURRENT PROTECTIVE DEVICE ARC-FLASH STUDY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes a computer-based, arc-flash study to determine the arc-flash hazard distance and the incident energy to which personnel could be exposed during work on or near electrical equipment.
 - 1. All revisions required to the study upon receiving recommendations and incorporating associated plan revisions shall be included at no additional cost.

1.3 DEFINITIONS

- A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.
- B. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.
- C. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.
- D. SCCR: Short-circuit current rating.
- E. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

1.4 ACTION SUBMITTALS

- A. Product Data: For computer software program to be used for studies.
- B. Other Action Submittals: Submit the following submittals after the approval of system protective devices submittals. Submittals may be in digital form.

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1. Arc-flash study input data, including completed computer program input data sheets.
2. Arc-flash study report; signed, dated, and sealed by a qualified professional engineer.
 - a. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.

1.5 INFORMATIONAL SUBMITTALS

- A. Product Certificates: For arc-flash hazard analysis software, certifying compliance with IEEE 1584 and NFPA 70E.

1.6 CLOSEOUT SUBMITTALS

- A. Maintenance procedures according to requirements in NFPA 70E shall be provided in the equipment manuals.
- B. Operation and Maintenance Procedures: In addition to items specified in Section 017823 "Operation and Maintenance Data," provide maintenance procedures for use by Owner's personnel that comply with requirements in NFPA 70E.

1.7 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
1. EDSA Micro Corporation.
 2. Power Analytics, Corporation.
 3. SKM Systems Analysis, Inc.
- B. Comply with IEEE 1584 and NFPA 70E.

2.2 ARC-FLASH STUDY REPORT CONTENT

- A. Executive summary.
- B. Study descriptions, purpose, basis and scope.
- C. One-line diagram, showing the following:
1. Protective device designations and ampere ratings.
 2. Cable size and lengths.
 3. Transformer kilovolt ampere (kVA) and voltage ratings.
 4. Motor and generator designations and kVA ratings.
 5. Switchgear, switchboard, motor-control center and panelboard designations.
- D. Study Input Data: As described in "Power System Data" Article.
- E. Short-Circuit Study Output: As specified in "Short Circuit Study Output" Paragraph in "Short-Circuit Study Report Contents" Article in Section 260572 "Overcurrent Protective Device Short-Circuit Study."
- F. Arc-Flash Study Output:
1. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
 - a. Voltage.
 - b. Calculated symmetrical fault-current magnitude and angle.
 - c. Fault-point X/R ratio.
 - d. No AC Decrement (NACD) ratio.
 - e. Equivalent impedance.
 - f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
 - g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.
- G. Incident Energy and Flash Protection Boundary Calculations:

1. Arcing fault magnitude.
2. Protective device clearing time.
3. Duration of arc.
4. Arc-flash boundary.
5. Working distance.
6. Incident energy.
7. Hazard risk category.
8. Recommendations for arc-flash energy reduction.

H. Fault study input data, case descriptions, and fault-current calculations including a definition of terms and guide for interpretation of the computer printout.

2.3 ARC-FLASH WARNING LABELS

A. Comply with requirements in Section 260553 "Identification for Electrical Systems." Produce a 3.5-by-5-inch thermal transfer label of high-adhesion polyester for each work location included in the analysis.

B. The label shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include the following information taken directly from the arc-flash hazard analysis:

1. Location designation.
2. Nominal voltage.
3. Flash protection boundary.
4. Hazard risk category.
5. Incident energy.
6. Working distance.
7. Engineering report number, revision number, and issue date.

C. Labels shall be machine printed, with no field-applied markings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine Project overcurrent protective device submittals. Proceed with arc-flash study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to arc-flash study may not be used in study.

3.2 ARC-FLASH HAZARD ANALYSIS

A. Comply with NFPA 70E and its Annex D for hazard analysis study.

B. Preparatory Studies:

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1. Short-Circuit Study Output: As specified in "Short-Circuit Study Output" Paragraph in "Short-Circuit Study Report Contents" Article in Section 260572 "Overcurrent Protective Device Short-Circuit Study."
 2. Protective Device Coordination Study Report Contents: As specified in "Protective Device Coordination Study Report Contents" Article in Section 260573 "Overcurrent Protective Device Coordination Study."
- C. Calculate maximum and minimum contributions of fault-current size.
1. The minimum calculation shall assume that the utility contribution is at a minimum and shall assume no motor load.
 2. The maximum calculation shall assume a maximum contribution from the utility and shall assume motors to be operating under full-load conditions.
- D. Calculate the arc-flash protection boundary and incident energy at locations in the electrical distribution system where personnel could perform work on energized parts.
- E. Include medium- and low-voltage equipment locations, except equipment rated 240-V ac or less fed from transformers less than 125 kVA.
- F. Safe working distances shall be specified for calculated fault locations based on the calculated arc-flash boundary, considering incident energy of 1.2 cal/sq.cm.
- G. Incident energy calculations shall consider the accumulation of energy over time when performing arc-flash calculations on buses with multiple sources. Iterative calculations shall take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors and generators shall be decremented as follows:
1. Fault contribution from induction motors should not be considered beyond three to five cycles.
 2. Fault contribution from synchronous motors and generators should be decayed to match the actual decrement of each as closely as possible (e.g., contributions from permanent magnet generators will typically decay from 10 per unit to three per unit after 10 cycles).
- H. Arc-flash computation shall include both line and load side of a circuit breaker as follows:
1. When the circuit breaker is in a separate enclosure.
 2. When the line terminals of the circuit breaker are separate from the work location.
- I. Base arc-flash calculations on actual overcurrent protective device clearing time. Cap maximum clearing time at two seconds based on IEEE 1584, Section B.1.2.

3.3 POWER SYSTEM DATA

- A. Obtain all data necessary for the conduct of the arc-flash hazard analysis.
1. Verify completeness of data supplied on the one-line diagram on Drawings. Call discrepancies to the attention of Architect.

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2. For new equipment, use characteristics submitted under the provisions of action submittals and information submittals for this Project.
3. For existing equipment, whether or not relocated, obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers.

B. Electrical Survey Data: Gather and tabulate the following input data to support study. Comply with recommendations in IEEE 1584 and NFPA 70E as to the amount of detail that is required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.

1. Product Data for overcurrent protective devices specified in other Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Obtain electrical power utility impedance at the service.
3. Power sources and ties.
4. Short-circuit current at each system bus, three phase and line-to-ground.
5. Full-load current of all loads.
6. Voltage level at each bus.
7. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in per cent, and phase shift.
8. For reactors, provide manufacturer and model designation, voltage rating and impedance.
9. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
10. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
11. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.
12. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
13. Motor horsepower and NEMA MG 1 code letter designation.
14. Low-voltage cable sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).
15. Medium-voltage cable sizes, lengths, conductor material, and cable construction and metallic shield performance parameters.

3.4 LABELING

A. Apply one arc-flash label for 600-V ac, 480-V ac, and applicable 208-V ac panelboards and disconnects and for each of the following locations:

1. Motor-control center.
2. Low-voltage switchboard.
3. Switchgear.
4. Medium-voltage switch.

5. Control panel.

3.5 APPLICATION OF WARNING LABELS

- A. Install the arc-fault warning labels under the direct supervision and control of the Arc-Flash Study Specialist.

3.6 DEMONSTRATION

- A. Engage the Arc-Flash Study Specialist to train Owner's maintenance personnel in the potential arc-flash hazards associated with working on energized equipment and the significance of the arc-flash warning labels.

END OF SECTION 260574

SECTION 260923 - LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Photoelectric switches (not used).
 - 2. Standalone daylight-harvesting switching controls.
 - 3. Indoor occupancy sensors.
 - 4. Lighting contactors.
 - 5. Emergency shunt relays (not used).

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: Show installation details for occupancy and light-level sensors.
 - 1. Interconnection diagrams showing field-installed wiring.
 - 2. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For each type of lighting control device to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 TIME SWITCHES (not used)

2.2 OUTDOOR PHOTOELECTRIC SWITCHES(not used)

2.3 DAYLIGHT-HARVESTING DIMMING CONTROLS

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. Cooper Industries, Inc.
2. Hubbell Building Automation, Inc.
3. Leviton Manufacturing Co., Inc.
4. Lithonia Lighting; Acuity Brands Lighting, Inc.
5. Watt Stopper.

B. System Description: Sensing daylight and electrical lighting levels, the system adjusts the indoor electrical lighting levels. As daylight increases, the lights are dimmed.

1. Lighting control set point is based on two lighting conditions:
 - a. When no daylight is present (target level).
 - b. When significant daylight is present.
2. System programming is done with two hand-held, remote-control tools.
 - a. Initial setup tool.
 - b. Tool for occupants to adjust the target levels by increasing the set point up to 25 percent, or by minimizing the electric lighting level.

C. Ceiling-Mounted Dimming Controls: Solid-state, light-level sensor unit, with separate controller unit, to detect changes in lighting levels that are perceived by the eye.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Sensor Output: 0- to 10-V dc to operate electronic dimming ballasts. Sensor is powered by controller unit.
3. Power Pack: Sensor has 24-V dc, Class 2 power source, as defined by NFPA 70.
4. Light-Level Sensor Set-Point Adjustment Range: 20 to 60 fc.

2.4 INDOOR OCCUPANCY SENSORS

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. Hubbell Building Automation, Inc.
2. Leviton Manufacturing Co., Inc.

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3. Lithonia Lighting; Acuity Brands Lighting, Inc.
 4. Lutron Electronics Co., Inc.
 5. Sensor Switch, Inc.
 6. Watt Stopper.
- B. General Requirements for Sensors: Wall- or ceiling-mounted, solid-state indoor occupancy sensors with a separate power pack.
1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 2. Operation: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn them off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
 3. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor is powered from the power pack.
 4. Power Pack: 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. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.
 5. Mounting:
 - a. Sensor: Suitable for mounting in any position on a standard outlet box.
 - b. Relay: Externally mounted through a 1/2-inch knockout in a standard electrical enclosure.
 - c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
 6. Indicator: Digital display, to show when motion is detected during testing and normal operation of sensor.
 7. Bypass Switch: Override the "on" function in case of sensor failure.
 8. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc; turn lights off when selected lighting level is present.
- C. Dual-Technology Type: Ceiling mounted; detect occupants in coverage area using PIR and ultrasonic detection methods. The particular technology or combination of technologies that control on-off functions is selectable in the field by operating controls on unit.
1. Sensitivity Adjustment: Separate for each sensing technology.
 2. Detector Sensitivity: Detect occurrences of 6-inch- minimum movement of any portion of a human body that presents a target of not less than 36 sq. in., and detect a person of average size and weight moving not less than 12 inches in either a horizontal or a vertical manner at an approximate speed of 12 inches/s.
 3. Detection Coverage:
 - a. Standard Height Units: In areas that have ceiling heights of 12 feet or lower, provide Watt Stopper unit DT-300 (or approved equal): Detect occupancy anywhere within a circular area up to 2000 square feet. Detectors shall be networkable to allow coverage of larger or irregularly shaped areas.
 - b. High Ceiling Units: In areas that have ceiling/mounting height over 12 feet up to 40 foot mounting including but not limited to Gymnasium, Auditorium, Cafeteria (commons) and forum spaces, provide Watt Stopper unit HB3x0 with L4 lens, or approved equal. Detect occupancy anywhere within a circular area up to 3500

square feet. Detectors shall be networkable to allow coverage of larger or irregularly shaped areas.

2.5 SWITCHBOX-MOUNTED OCCUPANCY SENSORS

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. Hubbell Building Automation, Inc.
2. Leviton Manufacturing Co., Inc.
3. Lutron Electronics Co., Inc.
4. Sensor Switch, Inc.
5. Watt Stopper.

B. General Requirements for Sensors: Automatic-wall-switch occupancy sensor, suitable for mounting in a single gang switchbox.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Operating Ambient Conditions: Dry interior conditions, 32 to 120 deg F.
3. Switch Rating: Not less than 800-VA LED at 120 V, 1200-VA LED at 277 V,

C. Wall-Switch Sensor:

1. Standard Range: 180-degree field of view, field adjustable from 180 to 40 degrees; with a minimum coverage area of 900 sq. ft..
2. Sensing Technology: Dual technology - PIR and ultrasonic.
3. Switch Type: SP.
4. Voltage: Dual voltage, 120 and 277 V; dual-technology type.
5. Ambient-Light Override: Concealed, field-adjustable, light-level sensor from 10 to 150 fc. The switch prevents the lights from turning on when the light level is higher than the set point of the sensor.
6. Concealed, field-adjustable, "off" time-delay selector at up to 30 minutes.
7. Adaptive Technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and helps eliminate false "off" switching.

2.6 HIGH-BAY OCCUPANCY SENSORS

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. Hubbell Building Automation, Inc.

B. General Description: Solid-state unit. The unit is designed to operate with the lamp and ballasts indicated.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

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2. Operation: Turn lights on when coverage area is occupied, and to half-power when unoccupied; with a time delay for turning lights to half-power that is adjustable over a minimum range of 1 to 16 minutes.
 3. Continuous Lamp Monitoring: When lamps are dimmed continuously for 24 hours, automatically turn lamps on to full power for 15 minutes for every 24 hours of continuous dimming.
 4. Operating Ambient Conditions: 32 to 149 deg F.
 5. Mounting: Threaded pipe.
 6. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
 7. Detector Technology: PIR.
- C. Detector Coverage: User selectable by interchangeable PIR lenses, suitable for mounting heights from 12 to 50 feet.
- D. Accessories: Obtain manufacturer's installation and maintenance kit with laser alignment tool for sensor positioning and power port connectors.

2.7 LIGHTING CONTACTORS

- 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. Allen-Bradley/Rockwell Automation.
 2. ASCO Power Technologies, LP.
 3. General Electric Company.
 4. Square D.
- B. Description: Electrically operated and electrically held, combination-type lighting contactors with nonfused disconnect, 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.
 4. Provide with control and pilot devices as indicated on Drawings, matching the NEMA type specified for the enclosure.
- C. Interface with DDC System for HVAC: Provide hardware interface to enable the DDC system for HVAC to monitor and control lighting contactors.
1. Monitoring: On-off status.
 2. Control: On-off operation.

- 2.8 EMERGENCY SHUNT RELAY(not used)
- 2.9 CONDUCTORS AND CABLES
- A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
 - B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
 - C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 14 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

- 3.1 SENSOR INSTALLATION
- A. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression systems, and partition assemblies.
 - B. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.
- 3.2 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 Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size is 1/2 inch.
 - B. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and non-power-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 Section 260553 "Identification for Electrical Systems."
 - 1. Identify controlled circuits in lighting contactors.
 - 2. Identify circuits or luminaires controlled by photoelectric and occupancy sensors at each sensor.
- B. Label time switches and contactors with a unique designation.

3.5 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Operational Test: After installing time switches and sensors, and after electrical circuitry has been energized, start units to confirm proper unit operation.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Lighting control devices will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

3.6 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months from 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.
 - 1. For occupancy and motion sensors, verify operation at outer limits of detector range. Set time delay to suit Owner's operations.
 - 2. For daylighting controls, adjust set points and deadband controls to suit Owner's operations.
 - 3. Align high-bay occupancy sensors using manufacturer's laser aiming tool.

3.7 DEMONSTRATION

- A. Coordinate demonstration of products specified in this Section with demonstration requirements for low-voltage, programmable lighting control systems specified in Section 260943.13 "Addressable-Fixture Lighting Controls" and Section 260943.23 "Relay-Based Lighting Controls."
- B. Train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices.

END OF SECTION 260923

SECTION 262200 - LOW-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes: Distribution, dry-type transformers rated 600 V and less, with capacities up to 1500 kVA.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each type and size of transformer.
 - 2. Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer.
- B. Shop Drawings:
 - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.
 - 3. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Source quality-control reports.
- B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

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

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- 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. Eaton Electrical Sector; Eaton Corporation.
 - 2. Siemens Power Transmission & Distribution, Inc.
 - 3. Square D; by Schneider Electric.
- B. Source Limitations: Obtain each transformer type from single source from single manufacturer.
- C. All panelboards, switchboards, circuit breakers, dry type transformers and disconnect switches shall be of the same manufacturer.

2.2 GENERAL TRANSFORMER REQUIREMENTS

- A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Transformers Rated 15 kVA and Larger: Comply with 10 CFR Part 431 (2016), DOE 2016 energy-efficiency levels as verified by testing according to NEMA TP 2.
- D. Cores: Electrical grade, non-aging silicon steel with high permeability and low hysteresis losses.
- E. Coils: Continuous windings without splices except for taps.
 - 1. Internal Coil Connections: Brazed or pressure type.
 - 2. Coil Material: Copper.
- F. Encapsulation: Transformers smaller than 30 kVA shall have core and coils completely resin encapsulated.
- G. Shipping Restraints: Paint or otherwise color code bolts, wedges, blocks, and other restraints that are to be removed after installation and before energizing. Use fluorescent colors that are easily identifiable inside the transformer enclosure.

2.3 DISTRIBUTION TRANSFORMERS

- A. Comply with NFPA 70, and list and label as complying with UL 1561.
- B. Cores: One leg per phase.
- C. Enclosure: Ventilated.
 - 1. NEMA 250, Type 2: Core and coil shall be encapsulated within resin compound to seal out moisture and air.
 - 2. KVA Ratings: Based on convection cooling only and not relying on auxiliary fans.
- D. Transformer Enclosure Finish: Comply with NEMA 250.
 - 1. Finish Color: Gray.
- E. Taps for Transformers 3 kVA and Smaller: None.
- F. Taps for Transformers 7.5 to 24 kVA: One 5 percent tap above and one 5 percent tap below normal full capacity.
- G. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity.
- H. Insulation Class, Smaller than 30 kVA: 185 deg C, UL-component-recognized insulation system with a maximum of 115-deg C rise above 40-deg C ambient temperature.
- I. Insulation Class, 30 kVA and Larger: 220 deg C, UL-component-recognized insulation system with a maximum of 150-deg C rise above 40-deg C ambient temperature.
- J. K-Factor Rating: Transformers indicated to be K-factor rated shall comply with UL 1561 requirements for nonsinusoidal load current-handling capability to the degree defined by designated K-factor.
 - 1. Unit shall not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor.
 - 2. Indicate value of K-factor on transformer nameplate.
 - 3. Unit shall meet requirements of NEMA TP 1 when tested according to NEMA TP 2 with a K-factor equal to one.
- K. Electrostatic Shielding: Each winding shall have an independent, single, full-width copper electrostatic shield arranged to minimize interwinding capacitance.
 - 1. Arrange coil leads and terminal strips to minimize capacitive coupling between input and output terminals.
 - 2. Include special terminal for grounding the shield.
- L. Neutral: Rated 200 percent of full load current for K-factor rated transformers.
- M. Wall Brackets: Manufacturer's standard brackets.
- N. Fungus Proofing: Permanent fungicidal treatment for coil and core.

- O. Low-Sound-Level Requirements: Maximum sound levels when factory tested according to IEEE C57.12.91, as follows:

1. 9 kVA and Less: 40dBA.
2. 30 to 50 kVA: 45dBA.
3. 51 to 150 kVA: 50dBA.
4. 151 to 300 kVA: 55dBA.
5. 301 to 500 kVA: 60dBA.
6. 501 to 750 kVA: 62dBA.
7. 751 to 1000 kVA: 64dBA.
8. 1001 to 1500 kVA: 65dBA.

2.4 IDENTIFICATION DEVICES

- A. Nameplates: Engraved, laminated-plastic or metal nameplate for each distribution transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Section 260553 "Identification for Electrical Systems."

2.5 SOURCE QUALITY CONTROL

- A. Test and inspect transformers according to IEEE C57.12.01 and IEEE C57.12.91.
1. Resistance measurements of all windings at the rated voltage connections and at all tap connections.
 2. Ratio tests at the rated voltage connections and at all tap connections.
 3. Phase relation and polarity tests at the rated voltage connections.
 4. No load losses, and excitation current and rated voltage at the rated voltage connections.
 5. Impedance and load losses at rated current and rated frequency at the rated voltage connections.
 6. Applied and induced tensile tests.
 7. Regulation and efficiency at rated load and voltage.
 8. Insulation Resistance Tests:
 - a. High-voltage to ground.
 - b. Low-voltage to ground.
 - c. High-voltage to low-voltage.
 9. Temperature tests.
- B. Factory Sound-Level Tests: Conduct prototype sound-level tests on production-line products.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.

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- B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.
- C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.
- D. Verify that ground connections are in place and requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.
- E. Environment: Enclosures shall be rated for the environment in which they are located. Covers for NEMA 250, Type 4X enclosures shall not cause accessibility problems.
- F. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install wall-mounted transformers level and plumb with wall brackets fabricated by transformer manufacturer.
 - 1. Coordinate installation of wall-mounted and structure-hanging supports with actual transformer provided.
- B. Install transformers level and plumb on a concrete base with vibration-dampening supports. Locate transformers away from corners and not parallel to adjacent wall surface.
- C. Construct concrete bases according to Section 033000 "Cast-in-Place Concrete" and anchor floor-mounted transformers according to manufacturer's written instructions and requirements in Section 260529 "Hangers and Supports for Electrical Systems."
 - 1. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.
- D. Secure transformer to concrete base according to manufacturer's written instructions.
- E. Secure covers to enclosure and tighten all bolts to manufacturer-recommended torques to reduce noise generation.
- F. Remove shipping bolts, blocking, and wedges.

3.3 CONNECTIONS

- A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

- C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.
- D. Provide flexible connections at all conduit and conductor terminations and supports to eliminate sound and vibration transmission to the building structure.

3.4 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
- B. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS for dry-type, air-cooled, low-voltage transformers. Certify compliance with test parameters.
- C. Remove and replace units that do not pass tests or inspections and retest as specified above.
- D. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

3.5 ADJUSTING

- A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 5 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.
- B. Connect buck-boost transformers to provide nameplate voltage of equipment being served, plus or minus 5 percent, at secondary terminals.
- C. Output Settings Report: Prepare a written report recording output voltages and tap settings.

3.6 CLEANING

- A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION 262200

SECTION 262413 - SWITCHBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

1. Service and distribution switchboards rated 600 V and less.
2. Surge protection devices.
3. Disconnecting and overcurrent protective devices.
4. Instrumentation.
5. Control power.
6. Accessory components and features.
7. Identification.

1.3 ACTION SUBMITTALS

- A. Product Data: For each switchboard, overcurrent protective device, surge protection device, ground-fault protector, accessory, and component.
 1. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
- B. Shop Drawings: For each switchboard and related equipment.
 1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
 2. Detail enclosure types for types other than NEMA 250, Type 1.
 3. Detail bus configuration, current, and voltage ratings.
 4. Detail short-circuit current rating of switchboards and overcurrent protective devices.
 5. Include descriptive documentation of optional barriers specified for electrical insulation and isolation.
 6. Detail utility company's metering provisions with indication of approval by utility company.
 7. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

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8. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer.
- B. Field Quality-Control Reports:
 1. Test procedures used.
 2. Test results that comply with requirements.
 3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For switchboards and components to include in emergency, operation, and maintenance manuals.
 1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - a. Routine maintenance requirements for switchboards and all installed components.
 - b. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
 - c. Time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: An employer of workers qualified as defined in NEMA PB 2.1 and trained in electrical safety as required by NFPA 70E.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Deliver switchboards in sections or lengths that can be moved past obstructions in delivery path.
- B. Remove loose packing and flammable materials from inside switchboards and install temporary electric heating (250 W per section) to prevent condensation.
- C. Handle and prepare switchboards for installation according to NEMA PB 2.1.

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1.8 FIELD CONDITIONS

- A. Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving switchboards into place.
- B. Unusual Service Conditions: NEMA PB 2, as follows:
 - 1. Ambient temperatures within limits specified.
 - 2. Altitude not exceeding 6600 feet.

1.9 COORDINATION

- A. Coordinate layout and installation of switchboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

1.10 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace switchboard enclosures, buswork, overcurrent protective devices, accessories, and factory installed interconnection wiring that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Three years from date of Substantial Completion.
- B. Manufacturer's Warranty: Manufacturer's agrees to repair or replace surge protection devices that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SWITCHBOARDS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Eaton Electrical Sector; Eaton Corporation.
 - 2. General Electric Company.
 - 3. Siemens Power Transmission & Distribution, Inc.
 - 4. Square D; by Schneider Electric.

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- B. Source Limitations: Obtain switchboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.
- C. All feeder breakers in switchboards shall have LSI (long time, short time and instantaneous) settings.
- D. All panelboards, switchboards, circuit breakers, dry type transformers and disconnect switches shall be of the same manufacturer.
- E. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchboards including clearances between switchboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- F. 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.
- G. Comply with NEMA PB 2.
- H. Comply with NFPA 70.
- I. Comply with UL 891.
- J. Front-Connected, Front-Accessible Switchboards:
 - 1. Main Devices: Fixed, individually mounted.
 - 2. Branch Devices: Panel mounted.
 - 3. Sections front and rear aligned.
- K. Front- and Side-Accessible Switchboards:
 - 1. Main Devices: Fixed, individually mounted.
 - 2. Branch Devices: Panel mounted.
 - 3. Section Alignment: Front and Rear aligned.
- L. Front- and Rear-Accessible Switchboards:
 - 1. Main Devices: Fixed, individually mounted.
 - 2. Branch Devices: Fixed individually mounted.
 - 3. Sections front and rear aligned aligned.
- M. Nominal System Voltage: Switchboard 1: 480Y/277 V, Switchboard 2: 208Y/120 V
- N. Main-Bus Continuous: Switchboard 1: 3000 A, Switchboard 2: 4000 A.
- O. Indoor Enclosures: Steel, NEMA 250, Type 1.
- P. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.
- Q. Barriers: Between adjacent switchboard sections.

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- R. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.
- S. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.
- T. Pull Box on Top of Switchboard:
 - 1. Adequate ventilation to maintain temperature in pull box within same limits as switchboard.
 - 2. Removable covers shall form top, front, and sides. Top covers at rear shall be easily removable for drilling and cutting.
 - 3. Bottom shall be insulating, fire-resistive material with separate holes for cable drops into switchboard.
 - 4. Cable supports shall be arranged to facilitate cabling and adequate to support cables indicated, including those for future installation.
- U. Buses and Connections: Three phase, four wire unless otherwise indicated.
 - 1. Provide phase bus arrangement A, B, C from front to back, top to bottom, and left to right when viewed from the front of the switchboard.
 - 2. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity.
 - 3. Phase- and Neutral-Bus Material: Tin-plated, high-strength, electrical-grade aluminum alloy with tin-plated aluminum circuit-breaker line connections.
 - 4. Copper feeder circuit-breaker line connections.
 - 5. Ground Bus: 1/4-by-2-inch hard-drawn copper of 98 percent conductivity, equipped with mechanical connectors for feeder and branch-circuit ground conductors.
 - 6. Main-Phase Buses and Equipment-Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
 - 7. Disconnect Links:
 - a. Isolate neutral bus from incoming neutral conductors.
 - b. Bond neutral bus to equipment-ground bus for switchboards utilized as service equipment or separately derived systems.
 - 8. Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with mechanical connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.
 - 9. Isolation Barrier Access Provisions: Permit checking of bus-bolt tightness.
- V. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

2.2 SURGE PROTECTION DEVICES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Advanced Protection Technologies Inc. (APT).
 - 2. Eaton Electrical Sector; Eaton Corporation.

3. General Electric Company.
4. Siemens Power Transmission & Distribution, Inc.
5. Square D; by Schneider Electric.

B. SPDs: Comply with UL 1449 third edition, Type 1.

1. SPDs with the following features and accessories:

- a. Integral disconnect switch.
- b. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
- c. Indicator light display for protection status.
- d. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
- e. Surge counter.

C. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than [**200 kA**] [**250kA**] [**300 kA**] <Insert value>. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.

D. Protection modes and UL 1449 (third edition) VPR for grounded wye circuits with [**480Y/277 V**] [**208Y/120 V**], three-phase, four-wire circuits shall not exceed the following:

1. Line to Neutral, Line to Ground: [**1200 V for 480Y/277 V**] [**700 V for 208Y/120 V**].
2. Line to Line: [**2000 V for 480Y/277 V**] [**1000 V for 208Y/120 V**].

E. Protection modes and UL 1449 VPR for 240/120 V, single-phase, three-wire circuits shall not exceed the following:

1. Line to Neutral, Line to Ground: 700 V.
2. Line to Line: 1000 V.

F. SCCR: Equal or exceed [**100 kA**] [**200 kA**] <Insert value>.

G. Nominal Rating: 20 kA.

2.3 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.

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3. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:
 - a. Instantaneous trip.
 - b. Long- and short-time pickup levels.
 - c. Long and short time adjustments.
 - d. Ground-fault pickup level, time delay, and I^2t response.
 4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
 5. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker; trip activation on fuse opening or on opening of fuse compartment door.
 6. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).
 7. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).
 8. MCCB Features and Accessories:
 - a. Standard frame sizes, trip ratings, and number of poles.
 - b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor material.
 - c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
 - d. Ground-Fault Protection: [**Integrally mounted**] [**Remote-mounted**] relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
 - e. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
 - f. Communication Capability: [**Circuit-breaker-mounted**] [**Universal-mounted**] [**Integral**] [**Din-rail-mounted**] communication module with functions and features compatible with power monitoring and control system specified in Section 260913 "Electrical Power Monitoring and Control."
 - g. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at [**55**] [**75**] percent of rated voltage.
 - h. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
 - i. Auxiliary Contacts: [**One SPDT switch**] [**Two SPDT switches**] with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
 - j. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
- B. Insulated-Case Circuit Breaker (ICCB): [**80**] [**100**] percent rated, sealed, insulated-case power circuit breaker with interrupting capacity rating to meet available fault current.
1. [**Fixed**] [**Drawout**] circuit-breaker mounting.
 2. Two-step, stored-energy closing.

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3. **[Standard] [Full]**-function, microprocessor-based trip units with interchangeable rating plug, trip indicators, and the following field-adjustable settings:
 - a. Instantaneous trip.
 - b. Time adjustments for long- and short-time pickup.
 - c. Ground-fault pickup level, time delay, and I^2t response.
 4. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
 5. Remote trip indication and control.
 6. Communication Capability: Web enabled integral Ethernet communication module and embedded Web server with factory-configured Web pages (HTML file format). Provide functions and features compatible with power monitoring and control system specified in Section 260913 "Electrical Power Monitoring and Control."
 7. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
 8. Control Voltage: 120-V ac.
- C. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.
- D. Fuses are specified in Section 262813 "Fuses."

2.4 INSTRUMENTATION

- A. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:
1. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:
 - a. Phase Currents, Each Phase: Plus or minus 0.5 percent.
 - b. Phase-to-Phase Voltages, Three Phase: Plus or minus 0.5 percent.
 - c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 0.5 percent.
 - d. Megawatts: Plus or minus 1 percent.
 - e. Megavars: Plus or minus 1 percent.
 - f. Power Factor: Plus or minus 1 percent.
 - g. Frequency: Plus or minus 0.1 percent.
 - h. Accumulated Energy, Megawatt Hours: Plus or minus 1 percent; accumulated values unaffected by power outages up to 72 hours.
 - i. Megawatt Demand: Plus or minus 1 percent; demand interval programmable from five to 60 minutes.
 2. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.
- B. Impulse-Totalizing Demand Meter:
1. Comply with ANSI C12.1.
 2. Suitable for use with switchboard watt-hour meter, including two-circuit totalizing relay.

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3. Cyclometer.
4. Four-dial, totalizing kilowatt-hour register.
5. Positive chart drive mechanism.
6. Capillary pen holding a minimum of one month's ink supply.
7. Roll chart with minimum 31-day capacity; appropriate multiplier tag.
8. Capable of indicating and recording 15 minute integrated demand of totalized system.

2.5 CONTROL POWER

- A. Control Circuits: 120-V ac, supplied through secondary disconnecting devices from control-power transformer.

2.6 ACCESSORY COMPONENTS AND FEATURES

- A. Portable Test Set: For testing functions of solid-state trip devices without removing from switchboard. Include relay and meter test plugs suitable for testing switchboard meters and switchboard class relays.

2.7 IDENTIFICATION

- A. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Receive, inspect, handle, and store switchboards according to NEMA PB 2.1.
 1. Lift or move panelboards with spreader bars and manufacturer-supplied lifting straps following manufacturer's instructions.
 2. Use rollers, slings, or other manufacturer-approved methods if lifting straps are not furnished.
 3. Protect from moisture, dust, dirt, and debris during storage and installation.
 4. Install temporary heating during storage per manufacturer's instructions.
- B. Examine switchboards before installation. Reject switchboards that are moisture damaged or physically damaged.
- C. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance of the Work or that affect the performance of the equipment.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

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3.2 INSTALLATION

- A. Install switchboards and accessories according to NEMA PB 2.1.
- B. Equipment Mounting: Install switchboards on concrete base, 4-inch nominal thickness. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."
 - 1. Install conduits entering underneath the switchboard, entering under the vertical section where the conductors will terminate. Install with couplings flush with the concrete base. Extend 2 inches above concrete base after switchboard is anchored in place.
 - 2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
 - 3. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - 4. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 5. Install anchor bolts to elevations required for proper attachment to switchboards.
 - 6. Anchor switchboard to building structure at the top of the switchboard if required or recommended by the manufacturer.
- C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, straps and brackets, and temporary blocking of moving parts from switchboard units and components.
- D. Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.
- E. Install filler plates in unused spaces of panel-mounted sections.
- F. Install overcurrent protective devices, surge protection devices, and instrumentation.
 - 1. Set field-adjustable switches and circuit-breaker trip ranges.
- G. Comply with NECA 1.

3.3 CONNECTIONS

- A. Comply with requirements for terminating feeder bus specified in Section 262500 "Enclosed Bus Assemblies." Drawings indicate general arrangement of bus, fittings, and specialties.
- B. Bond conduits entering underneath the switchboard to the equipment ground bus with a bonding conductor sized per NFPA 70.
- C. Support and secure conductors within the switchboard according to NFPA 70.
- D. Extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.

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3.4 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- C. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.5 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.
- B. Perform the following tests and inspections:
 - 1. Acceptance Testing:
 - a. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit. Open control and metering circuits within the switchboard, and remove neutral connection to surge protection and other electronic devices prior to insulation test. Reconnect after test.
 - b. Test continuity of each circuit.
 - 2. Test ground-fault protection of equipment for service equipment per NFPA 70.
 - 3. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 4. Correct malfunctioning units on-site where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 - 5. Perform the following infrared scan tests and inspections, and prepare reports:
 - a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchboard. Remove front panels so joints and connections are accessible to portable scanner.
 - b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchboard 11 months after date of Substantial Completion.
 - c. Instruments and Equipment:
 - 1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

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6. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

C. Switchboard will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573 "Overcurrent Protective Device Coordination Study."

3.7 PROTECTION

A. Temporary Heating: Apply temporary heat, to maintain temperature according to manufacturer's written instructions, until switchboard is ready to be energized and placed into service.

3.8 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories.

END OF SECTION 262413

SECTION 262416 - PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Distribution panelboards.
 - 2. Lighting and appliance branch-circuit panelboards.

1.3 DEFINITIONS

- A. SVR: Suppressed voltage rating.
- B. SPD: Surge Protection Device.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of panelboard, switching and overcurrent protective device, transient voltage suppression device, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For each panelboard and related equipment.
 - 1. Include dimensioned plans, elevations, sections, and details. 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. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
 - 6. Include wiring diagrams for power, signal, and control wiring.
 - 7. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.

1.5 INFORMATIONAL SUBMITTALS

A. Field Quality-Control Reports:

1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

B. Panelboard Schedules: For installation in panelboards.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.7 QUALITY ASSURANCE

A. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Series rating of panelboards is not acceptable.

E. Comply with NEMA PB 1.

F. Comply with NFPA 70.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.

B. Handle and prepare panelboards for installation according to NEMA PB 1.

1.9 PROJECT CONDITIONS

A. Environmental Limitations:

1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete.
2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - a. Ambient Temperature: Not exceeding 23 deg F to plus 104 deg F.
 - b. Altitude: Not exceeding 6600 feet.

B. Service Conditions: NEMA PB 1, usual service conditions, as follows:

1. Ambient temperatures within limits specified.
2. Altitude not exceeding 6600 feet.

1.10 COORDINATION

- A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

1.11 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.
 1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PANELBOARDS

- A. All panelboards, switchboards, circuit breakers, dry type transformers and disconnect switches shall be of the same manufacturer.
- B. All branch breakers over 60A and all main breakers in panelboards on the life safety, legally required and optional standby systems shall have LSI (long time, short time and instantaneous) settings. These panelboards shall be identified with a "HX" or "LX" prefix. Refer to the panelboard schedules and one-line diagram.

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- C. Enclosures: Flush and surface-mounted cabinets as indicated on the drawings.
 - 1. Rated for environmental conditions at installed location.
 - a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
 - b. Outdoor Locations: NEMA 250, Type 3R.
 - 2. Piano Type Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover or EZ-Trim.
 - 3. Finishes:
 - a. Panels and Trim: galvanized steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
 - b. Back Boxes: Galvanized steel.
 - 4. Directory Card: Inside panelboard door, mounted in transparent card holder.
- D. Incoming Mains Location: Top or bottom to match incoming conduit location.
- E. Phase, Neutral, and Ground Buses:
 - 1. Material: Hard-drawn copper, 98 percent conductivity.
 - 2. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
 - 3. Extra-Capacity Neutral Bus: Neutral bus rated 200 percent of phase bus and UL listed as suitable for nonlinear loads.
- F. 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.
 - 4. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
 - 5. Sub-feed (Double) Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
 - 6. Extra-Capacity Neutral Lugs: Rated 200 percent of phase lugs mounted on extra-capacity neutral bus.
- G. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.
- H. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals.
- I. All doors shall be keyed alike.

2.2 DISTRIBUTION PANELBOARDS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Eaton Electrical Sector; Eaton Corporation.
 2. General Electric Company.
 3. Siemens Industry, Inc.
 4. Square D.
- B. Panelboards: NEMA PB 1, power and feeder distribution type.
- C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
1. For doors more than 36 inches high, provide two latches, keyed alike.
- D. Mains: Circuit breaker or Lugs only per drawings.
- 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. Siemens Industry, Inc.
 2. General Electric Company.
 3. Square D.
 4. Eaton Electrical Sector; Eaton Corporation.
- B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.
- C. Mains: Circuit breaker or lugs only per the drawings.
- D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.
- E. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

2.4 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- 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. Eaton Electrical Sector; Eaton Corporation.
 2. General Electric Company.
 3. Siemens Industry, Inc.
 4. Square D.

- B. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.
1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
 3. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
 4. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).
 5. Arc-Fault Circuit Interrupter (AFCI) Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration.
 6. 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. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
 - d. Communication Capability: Circuit-breaker-mounted communication module with functions and features compatible with power monitoring and control system specified in Section 260913 "Electrical Power Monitoring and Control."
 - e. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
 - f. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage with field-adjustable 0.1- to 0.6-second time delay.
 - g. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts and "b" contacts operate in reverse of circuit-breaker contacts.
 - h. Multipole units enclosed in a single housing or factory assembled to operate as a single unit.
 - i. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.
 - j. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Receive, inspect, handle, and store panelboards according to NEMA PB 1.1.
- B. Examine panelboards before installation. Reject panelboards that are damaged or rusted or have been subjected to water saturation.

- C. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install panelboards and accessories according to NEMA PB 1.1.
- B. Equipment Mounting: Install panelboards on concrete bases, 4-inch nominal thickness. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."
 - 1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of base.
 - 2. For panelboards, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - 3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 4. Install anchor bolts to elevations required for proper attachment to panelboards.
 - 5. Attach panelboard to the vertical finished or structural surface behind the panelboard.
- C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.
- D. 90 inches to top of trim above finished floor unless otherwise indicated or as required to ensure that the operating handle of the top most switch or circuit breaker is not higher than 79" above the finished floor level.
- E. 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.
- F. Install overcurrent protective devices and controllers not already factory installed.
 - 1. Set field-adjustable, circuit-breaker trip ranges.
- G. Install filler plates in unused spaces.
- H. Stub four 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch empty conduits into raised floor space or below slab not on grade.
- I. Arrange conductors in gutters into groups and bundle and wrap with wire ties.
- J. Comply with NECA 1.
- K. Do not provide knock-outs in panelboard cans. Holes shall be field punched.
- L. Do not use gutter space for feeders. Verify location of incoming main breaker or lugs and provide appropriate top or bottom incoming feeder.

3.3 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Section 260553 "Identification for Electrical Systems."
- B. Create a directory to indicate installed circuit loads; incorporate Owner's final room designations. Obtain approval before installing. 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 Section 260553 "Identification for Electrical Systems."
- D. Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- B. 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 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. Panelboards will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports, including a certified report that identifies panelboards. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

- A. Adjust moving parts and operable component to function smoothly and lubricate as recommended by manufacturer.
- B. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573 "Overcurrent Protective Device Coordination Study."

- C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes.
 - 1. Measure as directed during period of normal system loading.
 - 2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
 - 3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
 - 4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

3.6 PROTECTION

- A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION 262416

SECTION 262726 - WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

1. Receptacles, receptacles with integral GFCI, and associated device plates.
2. Twist-locking receptacles.
3. Weather-resistant receptacles.
4. Wall-box dimmers.
5. Wall switches
6. Pendant cord-connector devices.
7. Cord and plug sets.
8. Floor service outlets and poke-through 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.
- D. RFI: Radio-frequency interference.
- E. SPD: Surge Protective Device.
- F. UTP: Unshielded twisted pair.

1.4 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:

1. Receptacles for Owner-Furnished Equipment: Match plug configurations.
2. Cord and Plug Sets: Match equipment requirements.

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: List of legends and description of materials and process used for pre-marking wall plates.
- C. Samples: One for each type of device and wall plate specified, in each color specified.

1.6 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.7 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing-label warnings and instruction manuals that include labeling conditions.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- 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. Cooper Wiring Devices, Inc.
 - 2. Hubbell.
 - 3. Leviton Manufacturing Co., Inc.
 - 4. Pass & Seymour/Legrand (Pass & Seymour).
- B. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.2 GENERAL WIRING-DEVICE REQUIREMENTS

- A. Wiring Devices, Components, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with NFPA 70.
- C. Devices that are manufactured for use with modular plug-in connectors may be substituted under the following conditions:
 - 1. Connectors shall comply with UL 2459 and shall be made with stranding building wire.
 - 2. Devices shall comply with the requirements in this Section.

2.3 STRAIGHT-BLADE RECEPTACLES

- A. Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596.
- B. Provide permanently marked receptacles "CONTROLLED" for automatic outlet control systems. Provide single or duplex marked receptacles are required by circuitry.
 - 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. Cooper Wiring Devices, Inc.
 - b. Hubbell.
 - c. Leviton Manufacturing Co., Inc.
 - d. Pass & Seymour/Legrand (Pass & Seymour).
- C. Tamper-Resistant Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498 Supplement, and FS W-C-596.
 - 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. Cooper Wiring Devices, Inc.
 - b. Hubbell Premise Wiring.
 - c. Leviton Manufacturing Co., Inc.
 - d. Pass & Seymour/Legrand (Pass & Seymour).

2.4 GFCI RECEPTACLES

- A. General Description:
 - 1. Straight blade, non-feed-through type.
 - 2. Comply with NEMA WD 1, NEMA WD 6, UL 498, UL 943 Class A, and FS W-C-596.
 - 3. Include indicator light that shows when the GFCI has malfunctioned and no longer provides proper GFCI protection.
- B. Duplex GFCI Convenience Receptacles, 125 V, 20 A:
 - 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. Cooper Wiring Devices, Inc.
 - b. Hubbell.
 - c. Leviton Manufacturing Co., Inc.
 - d. Pass & Seymour/Legrand (Pass & Seymour).
- C. Tamper-Resistant GFCI Convenience Receptacles, 125 V, 20 A:

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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. Hubbell.
 - b. Pass & Seymour/Legrand (Pass & Seymour).

2.5 TWIST-LOCKING RECEPTACLES

- A. Single Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration L5-20R, and UL 498.
 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. Cooper Wiring Devices, Inc.
 - b. Hubbell.
 - c. Leviton Manufacturing Co., Inc.
 - d. Pass & Seymour/Legrand (Pass & Seymour).
 2. Description:
 - a. Comply with NEMA WD 1, NEMA WD 6 Configuration L5-20R, and UL 498.
 - b. Equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.

2.6 PENDANT CORD-CONNECTOR DEVICES

- A. Description:
 1. Matching, locking-type plug and receptacle body connector.
 2. NEMA WD 6 Configurations L5-20P and L5-20R, heavy-duty grade, and FS W-C-596.
 3. Body: Nylon, with screw-open, cable-gripping jaws and provision for attaching external cable grip.

2.7 CORD AND PLUG SETS

- A. Description:
 1. Match voltage and current ratings and number of conductors to requirements of equipment being connected.
 2. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and ampacity of at least 130 percent of the equipment rating.
 3. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

2.8 TOGGLE SWITCHES

- A. Comply with NEMA WD 1, UL 20, and FS W-S-896.
- B. Switches, 120/277 V, 20 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. Single Pole:
 - 1) Cooper; AH1221.
 - 2) Hubbell; HBL1221.
 - 3) Leviton; 1221-2.
 - 4) Pass & Seymour; CSB20AC1.
 - b. Two Pole:
 - 1) Cooper; AH1222.
 - 2) Hubbell; HBL1222.
 - 3) Leviton; 1222-2.
 - 4) Pass & Seymour; CSB20AC2.
 - c. Three Way:
 - 1) Cooper; AH1223.
 - 2) Hubbell; HBL1223.
 - 3) Leviton; 1223-2.
 - 4) Pass & Seymour; CSB20AC3.
 - d. Four Way:
 - 1) Cooper; AH1224.
 - 2) Hubbell; HBL1224.
 - 3) Leviton; 1224-2.
 - 4) Pass & Seymour; CSB20AC4.
- C. Pilot-Light Switches, 20 A:
 - 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. Cooper Wiring Devices, Inc.
 - b. Hubbell.
 - c. Leviton Manufacturing Co., Inc.
 - d. Pass & Seymour/Legrand (Pass & Seymour).
 - 2. Description: Single pole, with neon-lighted handle, illuminated when switch is "off."
- D. Key-Operated Switches, 120/277 V, 20 A:

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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. Cooper Wiring Devices, Inc.
 - b. Hubbell.
 - c. Leviton Manufacturing Co., Inc.
 - d. Pass & Seymour/Legrand (Pass & Seymour).
2. Description: Single pole, with factory-supplied key in lieu of switch handle.

2.8 WALL-BOX DIMMERS

- A. Dimmer Switches: Modular, full-wave, solid-state units with integral, quiet on-off switches, with audible frequency and EMI/RFI suppression filters.
- B. Control: Continuously adjustable slider; with single-pole or three-way switching. Comply with UL 1472.
- C. LED Dimmer Switches: Modular; compatible with dimmer drivers; trim potentiometer to adjust low-end dimming; dimmer-driver combination capable of consistent dimming with low end not greater than 20 percent of full brightness.

2.9 WALL PLATES

- A. Single and combination types shall match corresponding wiring devices and match existing devices.
 1. Plate-Securing Screws: Metal with head color to match plate finish.
 2. Material for Finished Spaces: 0.035-inch- thick, satin-finished, Type 302 stainless steel.
 3. Material for Unfinished Spaces: Galvanized steel.
 4. Material for Damp Locations: Cast aluminum with spring-loaded lift cover, and listed and labeled for use in wet and damp locations.
- B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant, die-cast aluminum with lockable cover.

2.10 FLOOR SERVICE FITTINGS

- A. Type: Modular, flush-type, dual-service units suitable for wiring method used.
- B. Compartments: Barrier separates power from voice and data communication cabling.
- C. Service Plate: Rectangular, solid brass with satin finish.
- D. Power Receptacle: NEMA WD 6 Configuration 5-20R, gray finish, unless otherwise indicated.

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- E. Voice and Data Communication Outlet: Four modular, keyed, color-coded, RJ-45 jacks for UTP cable complying with requirements in Section 271500 "Communications Horizontal Cabling."

2.11 POKE-THROUGH ASSEMBLIES

- 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. Hubbell.
2. Pass & Seymour/Legrand (Pass & Seymour).
3. Square D; by Schneider Electric.
4. Thomas & Betts Corporation.
5. Wiremold / Legrand.

- B. Description:

1. Factory-fabricated and -wired assembly of below-floor junction box with multi-channeled, through-floor raceway/firestop unit and detachable matching floor service-outlet assembly.
2. Comply with UL 514 scrub water exclusion requirements.
3. Service-Outlet Assembly: Flush type with four simplex receptacles and space for four RJ-45 jacks complying with requirements in Section 271500 "Communications Horizontal Cabling."
4. Size: Selected to fit nominal 4-inch cored holes in floor and matched to floor thickness.
5. Fire Rating: Unit is listed and labeled for fire rating of floor-ceiling assembly.
6. Closure Plug: Arranged to close unused 4-inch cored openings and reestablish fire rating of floor.
7. Wiring Raceways and Compartments: For a minimum of four No. 12 AWG conductors and a minimum of four, four-pair cables that comply with requirements in Section 271500 "Communications Horizontal Cabling."

2.12 FINISHES

- A. Device Color:

1. Wiring Devices Connected to Normal Power System: Ivory unless otherwise indicated or required by NFPA 70 or device listing.
2. Wiring Devices Connected to Emergency Power System: Red.
3. SPD Devices: Blue.

- B. Wall Plate Color: to match existing device color.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Wall Plates for lighting switches and dimmers. Provide a steel wall plated fastened to the block wall to securely fasten the switch or dimmer so device cannot be easily removed. A steel recessed junction box is acceptable.
- B. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.
- C. Coordination with Other Trades:
 - 1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of boxes.
 - 2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
 - 3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
 - 4. Install wiring devices after all wall preparation, including painting, is complete.
- D. Conductors:
 - 1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.
 - 2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
 - 3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
- E. Device Installation:
 - 1. Replace devices that have been in temporary use during construction and that were installed before building finishing operations were complete.
 - 2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
 - 3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
 - 4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
 - 5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.
 - 6. Use a torque screwdriver when a torque is recommended or required by manufacturer.
 - 7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
 - 8. Tighten unused terminal screws on the device.
 - 9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.

F. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the right.
2. Install hospital-grade receptacles in patient-care areas with the ground pin or neutral blade at the top.

G. 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.

H. 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.

I. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

3.2 GFCI RECEPTACLES

A. Install non-feed-through-type GFCI receptacles where protection of downstream receptacles is not required.

3.3 IDENTIFICATION

A. Comply with Section 260553 "Identification for Electrical Systems."

B. Identify each receptacle with panelboard identification and circuit number. Use hot, stamped, or engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Test Instruments: Use instruments that comply with UL 1436.
2. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.

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 unacceptable.
3. Ground Impedance: Values of up to 2 ohms are acceptable.
4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
5. Using the test plug, verify that the device and its outlet box are securely mounted.
6. Tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

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- C. Wiring device will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

END OF SECTION 262726

SECTION 262813 - FUSES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

1. Cartridge fuses rated 600 V ac and less for use in the following:
 - a. Control circuits.
 - b. Enclosed controllers.
 - c. Enclosed switches.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for spare-fuse cabinets. Include the following for each fuse type indicated:
 1. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.
 - a. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
 - b. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.
 2. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
 3. Current-limitation curves for fuses with current-limiting characteristics.
 4. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse. Submit in electronic format suitable for use in coordination software and in PDF format.
 5. Coordination charts and tables and related data.
 6. Fuse sizes for elevator feeders and elevator disconnect switches.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
1. Ambient temperature adjustment information.
 2. Current-limitation curves for fuses with current-limiting characteristics.
 3. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse used on the Project. Submit in electronic format suitable for use in coordination software and in PDF format.
 4. Coordination charts and tables and related data.

1.5 FIELD CONDITIONS

- A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F or more than 100 deg F, apply manufacturer's ambient temperature adjustment factors to fuse ratings.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- 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. Cooper Bussmann; a division of Cooper Industries.
 2. Edison; a brand of Cooper Bussmann; a division of Cooper Industries.
 3. Littelfuse, Inc.
- B. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

2.2 CARTRIDGE FUSES

- A. Characteristics: NEMA FU 1, current-limiting, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.
1. Type RK-1: 600-V, zero- to 600-A rating, 200 kAIC, time delay.
 2. Type CC: 600-V, zero- to 30-A rating, 200 kAIC , time delay.
 3. Type J: 600-V, zero- to 600-A rating, 200 kAIC.
 4. Type L: 600-V, 601- to 6000-A rating, 200 kAIC, time delay.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Comply with NEMA FU 1 for cartridge fuses.

- D. Comply with NFPA 70.
- E. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.
- B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.
- C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.
- D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FUSE APPLICATIONS

- A. Cartridge Fuses:
 - 1. Feeders: Class RK1, time delay.
 - 2. Motor Branch Circuits: Class RK5, time delay.
 - 3. Large Motor Branch (601-4000 A): Class L, time delay.
 - 4. Power Electronics Circuits: Class J, high speed.
 - 5. Other Branch Circuits: Class RK1, time delay.
 - 6. Control Transformer Circuits: Class CC, time delay, control transformer duty.
 - 7. Provide open-fuse indicator fuses or fuse covers with open fuse indication.

3.3 INSTALLATION

- A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

3.4 IDENTIFICATION

- A. Install labels complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems" and indicating fuse replacement information inside of door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION 262813

SECTION 262816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Fusible switches.
 - 2. Non-fusible switches.
 - 3. Shunt trip switches.
 - 4. Molded-case circuit breakers (MCCBs).
 - 5. Enclosures.

1.3 DEFINITIONS

- A. NC: Normally closed.
- B. NO: Normally open.
- C. SPDT: Single pole, double throw.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
 - 1. Enclosure types and details for types other than NEMA 250, Type 1.
 - 2. Current and voltage ratings.
 - 3. Short-circuit current ratings (interrupting and withstand, as appropriate).
 - 4. Include evidence of NRTL listing for series rating of installed devices.
 - 5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
 - 6. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.
- 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.

1.5 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.
 1. Test procedures used.
 2. Test results that comply with requirements.
 3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
- B. Manufacturer's field service report.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
 2. Time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.

1.7 QUALITY ASSURANCE

- A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single source from single manufacturer.
- B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- D. Comply with NFPA 70.

1.8 PROJECT CONDITIONS

- A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 1. Ambient Temperature: Not less than minus 22 deg F and not exceeding 104 deg F.
 2. Altitude: Not exceeding 6600 feet.

1.9 COORDINATION

- A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

PART 2 - PRODUCTS

- 2.1 All panelboards, switchboards, circuit breakers, dry type transformers and disconnect switches shall be of the same manufacturer.

2.2 FUSIBLE SWITCHES

- 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. Eaton Electrical Sector; Eaton Corporation.
2. General Electric Company.
3. Siemens Industry, Inc.
4. Square D.

- B. Type HD, Heavy Duty, Single Throw, 240 or 480-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

- C. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
4. Auxiliary Contact Kit: One NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.
5. Hookstick Handle: Allows use of a hookstick to operate the handle.
6. Lugs: Mechanical type, suitable for number, size, and conductor material.
7. Accessory Control Power Voltage: Remote mounted and powered; 120-V ac.

2.3 NON-FUSIBLE SWITCHES

- 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. Eaton Electrical Sector; Eaton Corporation.
2. General Electric Company.
3. Siemens Industry, Inc.
4. Square D.

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- B. Type HD, Heavy Duty, Single Throw, 240 or 480-V -V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

- 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. Auxiliary Contact Kit: One NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.
 - 4. Hookstick Handle: Allows use of a hookstick to operate the handle.
 - 5. Lugs: Mechanical type, suitable for number, size, and conductor material.
 - 6. Accessory Control Power Voltage: Remote mounted and powered; 120-V ac.

2.4 SHUNT TRIP SWITCHES

- 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. Cooper Bussmann; a division of Cooper Industries.
 - 2. Littelfuse, Inc.
 - 3. Mersen USA.

- B. General Requirements: Comply with ASME A17.1, UL 50, and UL 98, with 200-kA interrupting and short-circuit current rating when fitted with Class J fuses.

- C. Switches: Three-pole, horsepower rated, with integral shunt trip mechanism and Class J fuse block; lockable handle with capability to accept three padlocks; interlocked with cover in closed position.

- D. Control Circuit: 120-V ac; obtained from integral control power transformer, with primary and secondary fuses with a control power transformer of enough capacity to operate shunt trip, connected pilot, and indicating and control devices.

- E. Accessories:
 - 1. Oiltight key switch for key-to-test function.
 - 2. Oiltight green ON pilot light.
 - 3. Isolated neutral lug; 100 percent rating.
 - 4. Mechanically interlocked auxiliary contacts that change state when switch is opened and closed.
 - 5. Form C alarm contacts that change state when switch is tripped.
 - 6. Three-pole, double-throw, fire-safety and alarm relay; 120-V ac coil voltage.
 - 7. Three-pole, double-throw, fire-alarm voltage monitoring relay complying with NFPA 72.

2.5 MOLDED-CASE CIRCUIT BREAKERS

- 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. Eaton Electrical Sector; Eaton Corporation.
 2. General Electric Company.
 3. Siemens Industry, Inc.
 4. Square D.
- B. General Requirements: Comply with UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents.
- C. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
- D. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
- E. Ground-Fault, Circuit-Interrupter (GFCI) Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
- F. Ground-Fault, Equipment-Protection (GFEP) Circuit Breakers: With Class B ground-fault protection (30-mA trip).
- G. Features and Accessories:
1. Standard frame sizes, trip ratings, and number of poles.
 2. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.
 3. Ground-Fault Protection: Comply with UL 1053; integrally mounted, self-powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
 4. Communication Capability: Circuit-breaker-mounted communication module with functions and features compatible with power monitoring and control system, specified in Section 260913 "Electrical Power Monitoring and Control."
 5. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
 6. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
 7. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
 8. Accessory Control Power Voltage: Integrally mounted, self-powered; 120-V ac.

2.6 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 250, Type 3R.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 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.

3.3 IDENTIFICATION

- A. Comply with requirements in Section 260553 "Identification for Electrical Systems."
 - 1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
 - 2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- B. Perform tests and inspections.
- C. 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.
- D. Tests and Inspections:

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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.
 3. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
- E. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.
- F. Prepare test and inspection reports, 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.

3.5 ADJUSTING

- A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.
- B. Set field-adjustable circuit-breaker trip ranges.

END OF SECTION 262816

SECTION 262913 - ENCLOSED CONTROLLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The drawings and general provisions of the Contract Documents apply to this Section.

1.2 SUMMARY

- A. This Section includes AC controllers rated 600 V or less that are supplied as enclosed units.

1.3 SUBMITTALS

- A. Product Data: For each type of enclosed controller. Include dimensions and manufacturer's technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For each enclosed controller.
 - 1. Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:
 - a. Enclosure types and details.
 - b. Nameplate legends.
 - c. Short circuit current rating of integrated unit.
 - d. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices in combination controllers.
 - 2. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer installed and field installed wiring.
- C. Maintenance Data: For enclosed controllers and components to include in maintenance manuals specified in Division 1. In addition to requirements specified in Division 1 Section "Closeout Procedures," include the following:
 - 1. Routine maintenance requirements for enclosed controllers and all installed components.
 - 2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
- D. Load Current and Overload Relay Heater List: Compile after motors have been installed and arrange to demonstrate that selection of heaters suits actual motor nameplate full load currents.
- E. Load Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that dip switch settings for motor running overload protection suit actual motor to be protected.

1.4 APPROVED MANUFACTURERS

- A. Schneider Electric/Square-D, Siemens and Eaton.

1.5 QUALITY ASSURANCE

- A. Source Limitations: Obtain enclosed controllers of a single type through one source from a single manufacturer.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a Nationally Recognized Testing Laboratory (NRTL) acceptable to the Authority Having Jurisdiction (AHJ) and marked for intended use.
- C. Comply with NFPA 70.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Store enclosed controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect enclosed controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.
- B. If stored in areas subjected to weather, cover enclosed controllers to protect from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside controllers; install electric heating of sufficient wattage to prevent condensation.

1.7 COORDINATION

- A. Coordinate layout and installation of enclosed controllers with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. It is realized that motor sizes and characteristics may change from the Contract Documents. Contractor is responsible for all coordination with the Owner, A&E, Contractors and Suppliers before ordering said equipment.
- C. Coordinate installation of roof curbs, equipment supports, and roof penetrations.
- D. Coordinate features of enclosed controllers and accessory devices with pilot devices and control circuits to which they connect.
- E. Coordinate features, accessories, and functions of each enclosed controller with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load.

PART 2 - PRODUCTS

2.1 MANUAL ENCLOSED CONTROLLERS

- A. Description: NEMA ICS 2, general purpose, Class A, with toggle action and overload element.

2.2 MAGNETIC ENCLOSED CONTROLLERS

- A. Description: NEMA ICS 2, Class A, full voltage, non-reversing, across the line, unless otherwise indicated.
- B. Control Power Transformer:
 - 1. All controllers shall contain a control power transformer with the following features:
 - a. Primary power for CPT shall be obtained from incoming power to controller.
 - b. Primary and secondary fusing.
 - c. Capacity to operate pilot and control devices, plus 100% spare capacity.
- C. Controller Disconnecting Means:
 - 1. All controllers shall incorporate a non-fused disconnecting means.
- D. Overload Relay:
 - 1. All controllers shall contain a solid state adjustable overload relay equal to "Motor Logic Plus" by Square-D with phase-imbalance-reversal-loss and over-under voltage protection with selectable time delay for manual and automatic reset.
- E. Accessories:
 - 1. All controllers shall have the following devices factory installed in enclosure cover:
 - a. Pilot Lights: LED with "Push To Test": Red-Run and Green-Stop.
 - b. Hand-Off-Auto selector switch.
 - c. External Reset Button.
 - 2. All controllers shall have auxiliary contacts: 2 sets of NO/NC.

2.3 ENCLOSURES

- A. Description: Flush or surface mounted cabinets as indicated. NEMA 250, Type 1, unless otherwise indicated to comply with environmental conditions at installed location.
 - 1. Outdoor Locations: NEMA 250, Type 3R.
 - 2. Kitchen Areas: NEMA 250, Type 4X, stainless steel.
 - 3. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
 - 4. Hazardous Areas: NEMA 250, Type 7C.

2.4 FACTORY FINISHES

- A. Finish: Manufacturer's standard paint applied to factory assembled and tested enclosed controllers before shipping.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and surfaces to receive enclosed controllers for compliance with requirements, installation tolerances and other conditions affecting performance.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

- A. Select features of each enclosed controller to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; duty cycle of motor, drive, and load; and configuration of pilot device and control circuit affecting controller functions.

3.3 INSTALLATION

- A. See Division 26 Section "Basic Materials and Methods" for general installation requirements.
- B. For control equipment at walls, bolt units to wall or mount on lightweight structural steel channels bolted to wall. For controllers not at walls, provide freestanding racks complying with Division 26 Section "Basic Materials and Methods."
- C. Install freestanding equipment on concrete bases complying with Division 3 Section "Cast-in-Place Concrete."

3.4 IDENTIFICATION

- A. Identify enclosed controller components and control wiring according to Division 26 Section "Electrical Identification."

3.5 CONTROL WIRING INSTALLATION

- A. Install wiring between enclosed controllers according to Division 26 Section "Conductors and Cables."
- B. Bundle, train, and support wiring in enclosures.
- C. Connect hand-off-automatic switch and other automatic control devices where applicable.
 - 1. Connect selector switches to bypass only manual and automatic control devices that have no safety functions when switch is in hand position.
 - 2. Connect selector switches with enclosed controller circuit in both hand and automatic positions for safety-type control devices such as low and high pressure cutouts, high temperature cutouts, and motor overload protectors.

3.6 CONNECTIONS

- A. Conduit installation requirements are specified in other Division 26 Sections. Drawings indicate general arrangement of conduit, fittings, and specialties.

- B. Ground equipment.
- 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 and UL 486B.

3.7 FIELD QUALITY CONTROL

- A. Prepare for acceptance tests as follows:
 - 1. Test insulation resistance for each enclosed controller bus, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- B. Testing: Perform the following field quality-control testing:
 - 1. Perform each electrical test and visual and mechanical inspection indicated in NETA ATS, Sections 7.5, 7.6, and 7.16.
 - 2. Certify compliance with test parameters.
 - 3. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
- 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.

3.8 ADJUSTING

- A. Set field adjustable switches and circuit breaker trip ranges.

3.9 CLEANING

- A. Clean enclosed controllers internally, on completion of installation, according to manufacturer's written instructions. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION 262913

SECTION 264313 – SURGE PROTECTION DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The drawings and general provisions of the Contract Documents apply to this Section.

1.2 SUMMARY

- A. This Section includes Surge Protective Devices (SPD) for low voltage power, control and communication equipment.

1.3 SUBMITTALS REQUIRED

- A. Product Data for the following:
1. For each type of product indicated.
- B. Product Certificates: Signed by manufacturers of SPD, certifying that products furnished comply with the following testing and labeling requirements:
1. UL 1283 certification.
 2. UL 1449 3rd Edition listing and classification and clamping voltages.
 3. NEMA LS-1: Certified single pulse surge current capacity testing documentation.
 4. ANSI/IEEE C62.41/62.45 certified documentation of the units minimum repetitive surge current capacity testing
- C. Maintenance Data: For SPD's to include maintenance manuals specified in Division 1.
- D. Warranties: Special warranties specified in this Section.

1.4 APPROVED MANUFACTURERS

Schneider Electric/Square-D, Siemens, Surge Suppression Inc., and Eaton.

1. All products submitted and supplied for this project under this specification as well as, 262816-Enclosed Switches and Circuit Breakers, 262413 Switchboards, 262416-Panelboards and 262200-Dry Type Transformers shall all be products from one manufacturer selected from the list above.

1.5 QUALITY ASSURANCE

- A. Source Limitations: Obtain switchboard and panelboard SPD's and accessories through one source from a single manufacturer.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a Nationally Recognized Testing Laboratory (NRTL) acceptable to the Authority Having Jurisdiction (AHJ) and marked for intended use.

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- C. IEEE Compliance: 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 for Surge Suppressor Testing."
- D. NEMA Compliance: Comply with NEMA LS 1, "Low Voltage Surge Protective Devices."
- E. UL Compliance: Comply with UL 1283, "Electromagnetic Interference Filters," and UL 1449 3rd Edition, "Surge Protective Devices."

1.6 PROJECT CONDITIONS

- F. Placing into Service: Do not energize service entrance equipment, MDP's or panelboards, until the SPD's are installed and properly connected.
- G. Service Conditions: Rate SPD's for continuous operation under the following conditions, unless otherwise indicated:
 - 1. Maximum Continuous Operating Voltage per UL 1449 3rd edition:
 - a. 480Y/277: 15% allowable fluctuation, 320V
 - b. 208Y/120: 25% allowable fluctuation, 150V
 - 2. Operating Temperature: 0 to 120 deg F.
 - 3. Humidity: 0 to 95%, non-condensing.
 - 4. Altitude: Less than 10,000 feet above sea level.

1.7 COORDINATION

- H. Coordinate layout and installation of SPD's and components with other construction, including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels. Notify Owner and A/E of any discrepancies prior to installation.
- I. Coordinate with panelboard supplier to install correct size circuit breaker for disconnecting means and in a location to minimize length and bends of connection conductors.

1.8 WARRANTY

- J. General Warranty: As provided for in section 260500 and special warranty below.
- K. Special Warranty: SPD's shall be completely warranted for 10 years from date of substantial completion. The warranty shall cover overexposures including damage caused by lightning. A "Warranty Letter" on manufacturer's letterhead shall be submitted with the O&M manuals and in the building warranty binder. This letter shall contain warranty start date, expiration, names and contact information.

PART 2 - PRODUCTS

2.1 SERVICE ENTRANCE, MDP AND PANELBOARD SURGE PROTECTIVE DEVICES

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- A. SPD Description: Basis of design, Square D EMA series. Units shall have the following features and accessories:
 - 1. Engineered solid state arrays of non-linear voltage dependent metal oxide varistors with matched operating characteristics.
 - 2. The suppression system shall not utilize silicon avalanche diodes (SADs) or other components which might short circuit the line, leading to interruption of normal power.
 - 3. Fuses, rated at 200 kA interrupting capacity.
 - 4. Internal connections: All full magnitude transient currents shall be conducted utilizing low impedance copper bus bars.
 - 5. Fabrication using bolted compression lugs for internal wiring.
 - 6. Redundant suppression circuits.
 - 7. Red and green LED indicator lights for power and protection status.
 - 8. Audible alarm, with silencing switch, to indicate when protection has failed.
 - 9. Surge event operations counter.

- B. Peak Surge Current Rating for Service Entrance devices: 240 kA per phase.

- C. Peak Surge Current Rating for MDP and Panelboard devices: 160 kA per phase.

- D. UL 1449 3rd Edition Voltage Protection Rating (VPR) shall be as follows:
 - 1. Line to Neutral:
 - a. 480Y/277: 1200V
 - b. 208Y/120: 700V
 - 2. Line to Ground:
 - a. 480Y/277: 1200V
 - b. 208Y/120: 700V
 - 3. Neutral to Ground:
 - a. 480Y/277: 1200V
 - b. 208Y/120: 700V
 - 4. Line to Line:
 - a. 480Y/277: 1800V
 - b. 208Y/120: 1200V

2.2 ENCLOSURES

- A. NEMA type matching the enclosure of panel or device being protected.

PART 3 - EXECUTION

3.1 INSTALLATION OF SURGE PROTECTIVE DEVICES

- A. All SPD's shall be externally mounted from the equipment being protected. Unit shall be fed from a branch mounted breaker sized per SPD manufacturer.

- B. Install devices with conductors sized in accordance with manufacturer's recommendations between SPD and points of attachment, as short and straight as possible. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.

3.2 CONNECTIONS

- A. Tighten electrical connectors and terminals according to manufacturer's published torque tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.3 FIELD QUALITY CONTROL

- A. Verify that electrical wiring installation complies with manufacturer's installation requirements.

END OF SECTION 264313

SECTION 265119 - LED INTERIOR LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Interior solid-state luminaires that use LED technology.
 - 2. Lighting fixture supports.

1.3 DEFINITIONS

- A. CCT: Correlated color temperature.
- B. CRI: Color Rendering Index.
- C. Fixture: See "Luminaire."
- D. IP: International Protection or Ingress Protection Rating.
- E. LED: Light-emitting diode.
- F. Lumen: Measured output of lamp and luminaire, or both.
- G. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.4 SUBSTITUTION LIGHT FIXTURES

- A. The light fixture layout in spaces indicated in the Contract Documents are the basis of design and are based upon photometric data, quality, construction and appearance of fixtures listed in the lighting fixture schedule. Substitute light fixtures of those listed are allowed. Provide the following:
 - 1. Provide all data as required for submittal package. Indicate variances with fixtures listed in lighting fixture schedule.

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Arrange in order of luminaire designation.
 - 2. Include data on features, accessories, and finishes.
 - 3. Include physical description and dimensions of luminaires.

4. Include emergency lighting units, including batteries and chargers.
 5. Include life, output (lumens, CCT, and CRI), and energy efficiency data.
 6. Photometric data and adjustment factors based on laboratory tests.
 - a. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.
- B. Shop Drawings: For nonstandard or custom luminaires.
1. Include plans, elevations, sections, and mounting and attachment details.
 2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 3. Include diagrams for power, signal, and control wiring.
- C. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.

1.6 INFORMATIONAL SUBMITTALS

- A. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- B. Product Certificates: For each type of luminaire.
- C. Product Test Reports: For each luminaire, for tests performed by manufacturer and witnessed by a qualified testing agency.
- D. Sample warranty.
- E. Product Certificates: For each type of luminaire.
- F. Product Test Reports: For each luminaire, for tests performed by manufacturer and witnessed by a qualified testing agency.
- G. Sample warranty.

1.7 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For luminaires and lighting systems to include in operation and maintenance manuals.
 1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

1.8 QUALITY ASSURANCE

- A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturer's laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.

- B. Provide luminaires from a single manufacturer for each luminaire type.
- C. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.10 WARRANTY

- A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.
- B. Warranty Period: Five year(s) from date of Substantial Completion.

1.11 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. Single Face Exit Signs: Furnish five single face exit signs. Include 100'-0" feet of wire and conduit, installed for each exit sign. Provide connection to the emergency circuit as directed by the owner.
 - 2. Double Face Exit Signs: Furnish five double face exit signs. Include 100'-0" feet of wire and conduit, installed for each exit sign. Provide connection to the emergency circuit as directed by the owner.

PART 2 - PRODUCTS

2.1 LUMINAIRE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. NRTL Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by an NRTL.
- C. Recessed Fixtures: Comply with NEMA LE 4.
- D. Bulb shape complying with ANSI C79.1.
- E. Lamp base complying with ANSI C81.61.
- F. CRI of minimum 80. CCT of 4000 K.

- G. Rated lamp life of 50,000 hours.
- H. Lamps dimmable from 100 percent to 0 percent of maximum light output.
- I. Internal driver:
 - 1. Minimum efficiency: 85% at full load.
 - 2. Minimum Operating Ambient Temperature: -20° C. (-4° F.).
 - 3. Input Voltage: 120 - 277V ($\pm 10\%$) at 60 Hz.
 - 4. Integral short circuit, open circuit, and overload protection.
 - 5. Power Factor: ≥ 0.95 .
 - 6. Total Harmonic Distortion: $\leq 20\%$.
 - 7. Comply with FCC 47 CFR Part 15.
- J. LED Modules:
 - 1. Comply with IES LM-79 and LM-80 requirements.
 - 2. Minimum CRI 80 and color temperature 4200° K unless otherwise specified in LIGHTING FIXTURE SCHEDULE.
 - 3. Minimum Rated Life: 50,000 hours per IES L70.
 - 4. Light output lumens as indicated in the LIGHTING FIXTURE SCHEDULE.
- K. Nominal Operating Voltage: 120/277 V ac.
- L. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.
- M. Housings:
 - 1. Stamped steel or extruded-aluminum housing and heat sink.
 - 2. Powder-coat finish.

2.2 CYLINDER

- A. Manufacturers: Subject to compliance with requirements, provide products as scheduled on the drawings.
- B. Minimum 1000 lumens. Minimum allowable efficacy of 80 lumens per watt.
- C. With integral mounting provisions.

2.3 DOWNLIGHT

- A. Manufacturers: Subject to compliance with requirements, provide products as scheduled on the drawings.
- B. Minimum 1,000 lumens. Minimum allowable efficacy of 80 lumens per watt.
- C. Universal mounting bracket.
- D. Integral junction box with conduit fittings.

2.4 LINEAR INDUSTRIAL

- A. Manufacturers: Subject to compliance with requirements, provide products as scheduled on the drawings.
- B. Minimum 5,000 lumens. Minimum allowable efficacy of 80 lumens per watt.

2.5 HIGHBAY, LINEAR

- A. Manufacturers: Subject to compliance with requirements, provide products as scheduled on the drawings.
Minimum 10,000 lumens. Minimum allowable efficacy of 80 lumens per watt.

2.6 RECESSED LINEAR

- A. Manufacturers: Subject to compliance with requirements, provide products as scheduled on the drawings.
- B. Minimum 3,000 lumens. Minimum allowable efficacy of 85 lumens per watt.
- C. Integral junction box with conduit fittings.

2.7 STRIP LIGHT

- A. Manufacturers: Subject to compliance with requirements, provide products as scheduled on the drawings.
- B. Minimum 750 lumens. Minimum allowable efficacy of 80 lumens per watt.
- C. Integral junction box with conduit fittings.

2.8 SURFACE MOUNT, LINEAR

- A. Manufacturers: Subject to compliance with requirements, provide products as scheduled on the drawings.
- B. Minimum 750 lumens. Minimum allowable efficacy of 80 lumens per watt.
- C. Integral junction box with conduit fittings.

2.9 SURFACE MOUNT, NONLINEAR

- A. Manufacturers: Subject to compliance with requirements, provide products as scheduled on the drawings.
- B. Minimum 750 lumens. Minimum allowable efficacy of 80 lumens per watt.

- C. Integral junction box with conduit fittings.

2.10 SUSPENDED, LINEAR

- A. Manufacturers: Subject to compliance with requirements, provide products as scheduled on the drawings.
- B. Minimum 3,000 lumens. Minimum allowable efficacy of 85 lumens per watt.

2.11 SUSPENDED, NONLINEAR

- A. Manufacturers: Subject to compliance with requirements, provide products as scheduled on the drawings.
- B. Minimum 3,000 lumens. Minimum allowable efficacy of 85 lumens per watt.
- C. Integral junction box with conduit fittings.

2.12 MATERIALS

- A. Metal Parts:
 - 1. Free of burrs and sharp corners and edges.
 - 2. Sheet metal components shall be steel unless otherwise indicated.
 - 3. Form and support to prevent warping and sagging.
- B. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.
- C. Diffusers and Globes:
 - 1. Prismatic acrylic
 - 2. Retain "Acrylic Diffusers" Subparagraph below if fifth or sixth option in "Diffusers and Globes" Paragraph above is retained.
 - 3. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
 - 4. Glass: Annealed crystal glass unless otherwise indicated.
 - 5. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.
- D. Housings:
 - 1. Stamped steel or extruded-aluminum housing and heat sink.
 - 2. Powder-coat finish.

- E. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Locate labels where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.
 - 1. Label shall include the following lamp characteristics:
 - a. "USE ONLY" and include specific lamp type.
 - b. Lamp diameter, shape, size, wattage, and coating.
 - c. CCT and CRI for all luminaires.

2.13 METAL FINISHES

- A. Variations in finishes are unacceptable in the same piece. Variations in finishes of adjoining components are acceptable if they are within the range of approved Samples and if they can be and are assembled or installed to minimize contrast.

2.14 LUMINAIRE FIXTURE SUPPORT COMPONENTS

- A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.
- B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as luminaire.
- C. Wires: ASTM A 641/A 641 M, Class 3, soft temper, zinc-coated steel, 12 gage.
- D. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.
- E. Hook Hangers: Integrated assembly matched to luminaire, line voltage, and equipment with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before fixture installation. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 TEMPORARY LIGHTING

- A. If approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is sufficiently complete, clean luminaires used for temporary lighting and install new lamps.

3.3 INSTALLATION

- A. Comply with NECA 1.
- B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.
- C. Install lamps in each luminaire.
- D. Supports:
 - 1. Sized and rated for luminaire weight.
 - 2. Able to maintain luminaire position after cleaning and relamping.
 - 3. Provide support for luminaire without causing deflection of ceiling or wall.
 - 4. Luminaire mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and vertical force of 400 percent of luminaire weight.
- E. Flush-Mounted Luminaire Support:
 - 1. Secured to outlet box.
 - 2. Attached to ceiling structural members at four points equally spaced around circumference of luminaire.
 - 3. Trim ring flush with finished surface.
- F. Wall-Mounted Luminaire Support:
 - 1. Attached to structural members in walls.
 - 2. Do not attach luminaires directly to gypsum board.
- G. Ceiling-Mounted Luminaire Support:
 - 1. Ceiling mount with 5/32-inch diameter aircraft cable supports adjustable to 120 inches in length.
 - 2. Ceiling mount with four-point pendant mount with 5/32-inch- diameter aircraft cable supports adjustable to 120 inches in length.
- H. Suspended Luminaire Support:
 - 1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
 - 2. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of luminaire oscillations. Support outlet box vertically to building structure using approved devices.
 - 3. Continuous Rows of Luminaires: Use tubing or stem for wiring at one point and wire support for suspension for each unit length of luminaire chassis, including one at each end.
 - 4. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.
- I. Ceiling-Grid-Mounted Luminaires:
 - 1. Secure to any required outlet box.

2. Secure luminaire to the luminaire opening using approved fasteners in a minimum of four locations, spaced near corners of luminaire.
 3. Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.
- J. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

3.4 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
 2. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.
- B. Luminaire will be considered defective if it does not pass operation tests and inspections.
- C. Prepare test and inspection reports.

3.6 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied conditions. Make up to two visits to Project during other-than-normal hours for this purpose. Some of this work may be required during hours of darkness.
1. During adjustment visits, inspect all luminaires. Replace lamps or luminaires that are defective.
 2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
 3. Adjust the aim of luminaires in the presence of the Architect.

END OF SECTION 265119

SECTION 265619 – LED EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Exterior solid-state luminaires that are designed for and exclusively use LED lamp technology.
 - 2. Luminaire supports.
 - 3. Luminaire-mounted photoelectric relays.

1.3 DEFINITIONS

- A. CCT: Correlated color temperature.
- B. CRI: Color rendering index.
- C. Fixture: See "Luminaire."
- D. IP: International Protection or Ingress Protection Rating.
- E. Lumen: Measured output of lamp and luminaire, or both.
- F. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.4 SUBSTITUTION LIGHT FIXTURES

- A. The light fixture layout in spaces indicated in the Contract Documents are the basis of design and are based upon photometric data, quality, construction and appearance of fixtures listed in the lighting fixture schedule. Substitute light fixtures of those listed are allowed. Provide the following:
 - 1. Provide all data as required for submittal package. Indicate variances with fixtures listed in lighting fixture schedule.

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of luminaire.

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1. Arrange in order of luminaire designation.
2. Include data on features, accessories, and finishes.
3. Include physical description and dimensions of luminaire.
4. Lamps, include life, output (lumens, CCT, and CRI), and energy-efficiency data.
5. Photometric data and adjustment factors based on laboratory tests, complying.
 - a. Manufacturer's Certified Data: Photometric data certified by manufacturers laboratory with a current accreditation under the NVLAP for Energy Efficient Lighting Products.
6. Wiring diagrams for power, control, and signal wiring.
7. Photoelectric relays.
8. Means of attaching luminaires to supports and indication that the attachment is suitable for components involved.

B. Shop Drawings: For nonstandard or custom luminaires.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.

1.6 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For testing laboratory providing photometric data for luminaires.
- B. Product Certificates: For each type of the following:
 1. Luminaire.
 2. Photoelectric relay.
- C. Product Test Reports: For each luminaire, for tests performed by manufacturer and witnessed by a qualified testing agency.
- D. Source quality-control reports.
- E. Sample warranty.

1.7 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For luminaires to include in operation and maintenance manuals.
 1. Provide a list of all lamp types used on Project. Use ANSI and manufacturers' codes.
 2. Provide a list of all photoelectric relay types used on Project; use manufacturers' codes.

1.8 QUALITY ASSURANCE

- A. Provide luminaires from a single manufacturer for each luminaire type.
- B. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.
- C. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering prior to shipping.

1.10 FIELD CONDITIONS

- A. Verify existing and proposed utility structures prior to the start of work associated with luminaire installation.
- B. Mark locations of exterior luminaires for approval by Architect prior to the start of luminaire installation.

1.11 WARRANTY

- A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Structural failures, including luminaire support components.
 - b. Faulty operation of luminaires and accessories.
 - c. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
 - 2. Warranty Period: 2 year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 LUMINAIRE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. NRTL Compliance: Luminaires shall be listed and labeled for indicated class and division of hazard by an NRTL.

- C. UL Compliance: Comply with UL 1598 and listed for wet location.
- D. Lamp base complying with ANSI C81.61 or IEC 60061-1.
- E. Bulb shape complying with ANSI C79.1.
- F. CRI of minimum 70. CCT of 5000 K.
- G. L70 lamp life of 50,000 hours.
- H. Lamps dimmable from 100 percent to 0 percent of maximum light output.
- I. Internal driver.
- J. Nominal Operating Voltage: 120/ 277 V ac.
- K. In-line Fusing: Separate in-line fuse for each luminaire.
- L. Lamp Rating: Lamp marked for outdoor use.
- M. Source Limitations: Obtain luminaires from single source from a single manufacturer.
- N. Source Limitations: For luminaires, obtain each color, grade, finish, type, and variety of luminaire from single source with resources to provide products of consistent quality in appearance and physical properties.

2.2 LUMINAIRE TYPES

- A. Area and Site:
 - 1. Manufacturers: Subject to compliance with requirements, provide products as scheduled on the drawings.
 - 2. Luminaire Shape: Square.
 - 3. Mounting: Pole with cast-aluminum arm, 11 inches in length.
 - 4. Luminaire-Mounting Height: As indicated on the drawings.
 - 5. Distribution: As indicated on the photometric report.
 - 6. Materials for "Diffusers and Globes" and "Housings" subparagraphs below may specific to each type of luminaire. General requirements for subparagraphs are specified in separate articles toward the end of Part 2.
 - 7. Diffusers and Globes: Prismatic acrylic.
 - 8. Housings:
 - a. Cast-aluminum housing and heat sink.
 - b. Powder-coat finish.
- B. Canopy:
 - 1. Manufacturers: Subject to compliance with requirements, provide products as scheduled on the drawings.
 - 2. Diffusers and Globes: Prismatic acrylic.

3. Housings:
 - a. Cast-aluminum housing and heat sink.
 - b. Powder-coat finish.

2.3 MATERIALS

- A. Metal Parts: Free of burrs and sharp corners and edges.
- B. Sheet Metal Components: Corrosion-resistant aluminum. Form and support to prevent warping and sagging.
- C. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses.
- D. Diffusers and Globes:
 1. Acrylic Diffusers: 100 percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
 2. Glass: Annealed crystal glass unless otherwise indicated.
 3. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.
- E. Lens and Refractor Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.
- F. Reflecting surfaces shall have minimum reflectance as follows unless otherwise indicated:
 1. White Surfaces: 85 percent.
 2. Specular Surfaces: 83 percent.
 3. Diffusing Specular Surfaces: 75 percent.
- G. Housings:
 1. Rigidly formed, weather- and light-tight enclosure that will not warp, sag, or deform in use.
 2. Provide filter/breather for enclosed luminaires.
- H. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.
 1. Label shall include the following lamp characteristics:
 - a. "USE ONLY" and include specific lamp type.
 - b. Lamp diameter, shape, size, wattage and coating.
 - c. CCT and CRI for all luminaires.

2.4 FINISHES

- A. Variations in Finishes: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.
- B. Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and -tested luminaire before shipping. Where indicated, match finish process and color of pole or support materials.
- C. Factory-Applied Finish for Aluminum luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
 - 1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
 - 2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20 requirements; and seal aluminum surfaces with clear, hard-coat wax.
 - 3. Class I, Clear-Anodic Finish: AA-M32C22A41 (Mechanical Finish: Medium satin; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.
 - 4. Class I, Color-Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: Medium satin; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker), complying with AAMA 611.
 - a. Color: Dark bronze.
- D. Factory-Applied Finish for Steel luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
 - 1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1 or SSPC-SP 8.
 - 2. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.
 - a. Color: As selected from manufacturer's standard catalog of colors.
 - b. Color: Match Architect's sample of manufacturer's standard color.
 - c. Color: As selected by Architect from manufacturer's full range.

2.5 LUMINAIRE SUPPORT COMPONENTS

- A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for luminaire electrical conduit to verify actual locations of conduit connections before luminaire installation.
- C. Examine walls, roofs, and canopy ceilings for suitable conditions where luminaires will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 TEMPORARY LIGHTING

- A. If approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is substantially complete, clean luminaires used for temporary lighting and install new lamps.

3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Comply with NECA 1.
- B. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.
- C. Install lamps in each luminaire.
- D. Fasten luminaire to structural support.
- E. Supports:
 - 1. Sized and rated for luminaire weight.
 - 2. Able to maintain luminaire position after cleaning and relamping.
 - 3. Support luminaires without causing deflection of finished surface.
 - 4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and a vertical force of 400 percent of luminaire weight.
- F. Wall-Mounted Luminaire Support:
 - 1. Attached to structural members in walls.
- G. Wiring Method: Install cables in raceways. Conceal raceways and cables.
- H. Install luminaires level, plumb, and square with finished grade unless otherwise indicated.
- I. Coordinate layout and installation of luminaires with other construction.

- J. Adjust luminaires that require field adjustment or aiming. Include adjustment of photoelectric device to prevent false operation of relay by artificial light sources, favoring a north orientation.
- K. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" and 260533 "Raceways and Boxes for Electrical Systems" for wiring connections and wiring methods.

3.4 CORROSION PREVENTION

- A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.
- B. Steel Conduits: Comply with Section 260533 "Raceways and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch-thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.5 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.6 FIELD QUALITY CONTROL

- A. Inspect each installed luminaire for damage. Replace damaged luminaires and components.
- B. Perform the following tests and inspections:
 - 1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
 - 2. Verify operation of photoelectric controls.
- C. Illumination Tests:
 - 1. Measure light intensities at night. Use photometers with calibration referenced to NIST standards. Comply with the following IES testing guide(s):
 - a. IES LM-5.
 - b. IES LM-50.
 - c. IES LM-52.
 - d. IES LM-64.
 - e. IES LM-72.
 - 2. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
- D. Luminaire will be considered defective if it does not pass tests and inspections.

- E. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

3.7 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain luminaires and photocell relays.

3.8 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied conditions. Make up to two visits to Project during other-than-normal hours for this purpose. Some of this work may be required during hours of darkness.
 - 1. During adjustment visits, inspect all luminaires. Replace lamps or luminaires that are defective.
 - 2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
 - 3. Adjust the aim of luminaires in the presence of the Architect.

END OF SECTION 265619

SECTION 270500 - COMMON WORK RESULTS FOR COMMUNICATIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Communications equipment coordination and installation.
 - 2. Sleeves for pathways and cables.
 - 3. Sleeve seals.
 - 4. Grout.
 - 5. Common communications installation requirements.

1.3 DEFINITIONS

- A. EPDM: Ethylene-propylene-diene terpolymer rubber.
- B. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

- A. Product Data: For sleeve seals.

1.5 COORDINATION

- A. Coordinate arrangement, mounting, and support of communications equipment:
 - 1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
 - 2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
 - 3. To allow right of way for piping and conduit installed at required slope.
 - 4. So connecting pathways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.
- B. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

COLONIAL HEIGHTS HIGH SCHOOL RENOVATION/ADDITION
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- C. Coordinate location of access panels and doors for communications items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08 Section "Access Doors and Frames."
- D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

PART 2 - PRODUCTS

2.1 SLEEVES FOR PATHWAYS AND 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. Sleeves for Rectangular Openings: Galvanized sheet steel.
 - 1. Minimum Metal Thickness:
 - a. For sleeve cross-section rectangle perimeter less than 50 inches and no side more than 16 inches, thickness shall be 0.052 inch.
 - b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches and 1 or more sides equal to, or more than, 16 inches, thickness shall be 0.138 inch.

2.2 SLEEVE SEALS

- A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and pathway or cable.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Advance Products & Systems, Inc.
 - b. Calpico, Inc.
 - c. Metraflex Co.
 - d. Pipeline Seal and Insulator, Inc.
 - 2. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of pathway or cable.
 - 3. Pressure Plates: Carbon steel. Include two for each sealing element.
 - 4. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.3 GROUT

- A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

PART 3 - EXECUTION

3.1 COMMON REQUIREMENTS FOR COMMUNICATIONS INSTALLATION

- A. Comply with NECA 1.
- B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
- C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.
- D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both communications equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.
- E. Right of Way: Give to piping systems installed at a required slope.

3.2 SLEEVE INSTALLATION FOR COMMUNICATIONS PENETRATIONS

- A. Communications penetrations occur when pathways, cables, wireways, or cable trays penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.
- 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. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
- D. 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.
- E. Cut sleeves to length for mounting flush with both surfaces of walls.
- F. Extend sleeves installed in floors 2 inches above finished floor level.
- G. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and pathway or cable, unless indicated otherwise.
- H. Seal space outside of sleeves with grout for penetrations of concrete and masonry

1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.
 - I. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and pathway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants."
 - J. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pathway and cable penetrations. Install sleeves and seal pathway and cable penetration sleeves with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping."
 - K. Roof-Penetration Sleeves: Seal penetration of individual pathways and cables with flexible boot-type flashing units applied in coordination with roofing work.
 - L. Aboveground, Exterior-Wall Penetrations: Seal penetrations using cast-iron pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
 - M. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between pathway or cable and sleeve for installing mechanical sleeve seals.

3.3 SLEEVE-SEAL INSTALLATION

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

3.4 FIRESTOPPING

- A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for communications installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

END OF SECTION 270500

SECTION 270528 - PATHWAYS FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Metal conduits and fittings.
2. Nonmetallic conduits and fittings.
3. Boxes, enclosures, and cabinets.
4. Handholes and boxes for exterior underground cabling.

B. Related Requirements:

1. Section 260543 "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks, manholes, and underground utility construction.
2. Section 260533 "Raceways and Boxes for Electrical Systems" for conduits, wireways, surface raceways, boxes, enclosures, cabinets, handholes, and faceplate adapters serving electrical systems.
3. Section 280528 "Pathways for Electronic Safety and Security" for conduits, surface pathways, innerduct, boxes, and faceplate adapters serving electronic safety and security.

1.3 DEFINITIONS

- A. ARC: Aluminum rigid conduit.
- B. GRC: Galvanized rigid steel conduit.
- C. IMC: Intermediate metal conduit.

1.4 ACTION SUBMITTALS

- A. Product Data: For surface pathways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.
- B. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Pathway routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:
 - 1. Structural members in paths of pathway groups with common supports.
 - 2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.
- B. Qualification Data: For professional engineer.
- C. Seismic Qualification Certificates: For pathway racks, enclosures, cabinets, equipment racks and their mounting provisions, including those for internal components, from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which certification is based and their installation requirements.
 - 4. Detailed description of conduit support devices and interconnections on which certification is based and their installation requirements.
- D. Source quality-control reports.

PART 2 - PRODUCTS

2.1 METAL CONDUITS AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. AFC Cable Systems; a part of Atkore International.
 - 2. Allied Tube & Conduit; a part of Atkore International.
 - 3. Alpha Wire.
 - 4. Southwire Company.
- B. General Requirements for Metal Conduits and Fittings:
 - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 2. Comply with TIA-569-B.
- C. GRC: Comply with ANSI C80.1 and UL 6.
- D. ARC: Comply with ANSI C80.5 and UL 6A.
- E. IMC: Comply with ANSI C80.6 and UL 1242.

- F. PVC-Coated Steel Conduit: PVC-coated IMC.
 - 1. Comply with NEMA RN 1.
 - 2. Coating Thickness: 0.040 inch, minimum.
- G. EMT: Comply with ANSI C80.3 and UL 797.
- H. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.
 - 1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886 and NFPA 70.
 - 2. Fittings for EMT:
 - a. Material: Steel or die cast.
 - b. Type: compression.
 - 3. Expansion Fittings: PVC or steel to match conduit type, complying with UL-467, rated for environmental conditions where installed, and including flexible external bonding jumper.
 - 4. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch, with overlapping sleeves protecting threaded joints.
- I. Joint Compound for IMC, GRC, or ARC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 NONMETALLIC CONDUITS AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. AFC Cable Systems; a part of Atkore International.
 - 2. Allied Tube & Conduit; a part of Atkore International.
 - 3. Electri-Flex Company.
 - 4. RACO; Hubbell.
 - 5. Thomas & Betts Corporation; A Member of the ABB Group.
- B. General Requirements for Nonmetallic Conduits and Fittings:
 - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 2. Comply with TIA-569-B.
- C. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.
- D. Rigid HDPE: Comply with UL 651A.
- E. Continuous HDPE: Comply with UL 651B.

- F. RTRC: Comply with UL 1684A and NEMA TC 14.
- G. Fittings for RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.
- H. Solvent cements and adhesive primers shall have a VOC content of 510 and 550 g/L or less, respectively, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- I. Solvent cements and adhesive primers shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.3 BOXES, ENCLOSURES, AND CABINETS

- 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. Carlou; a brand of Thomas & Betts Corporation.
 - 2. Quazite: Hubbell Power Systems, Inc.
 - 3. RACO; Hubbell.
 - 4. Thomas & Betts Corporation; A Member of the ABB Group.
 - 5. Wiremold / Legrand.
- B. General Requirements for Boxes, Enclosures, and Cabinets:
 - 1. Comply with TIA-569-B.
 - 2. Boxes, enclosures and cabinets installed in wet locations shall be listed for use in wet locations.
- C. Sheet-Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.
- D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.
- E. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
- F. Metal Floor Boxes:
 - 1. Material: Cast metal.
 - 2. Type: Fully adjustable.
 - 3. Shape: Rectangular.
 - 4. Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- G. Nonmetallic Floor Boxes: Nonadjustable, rectangular.

1. Listing and Labeling: Nonmetallic floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - H. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
 - I. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, cast aluminum with gasketed cover.
 - J. Device Box Dimensions: 4 inches square by 2-1/8 inches deep.
 - K. Gangable boxes are prohibited.
 - L. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.
 - M. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1 Type 3R with continuous-hinge cover with flush latch unless otherwise indicated.
 1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
 2. Nonmetallic Enclosures:
 - a. Material: Plastic.
 - b. Finished inside with radio-frequency-resistant paint.
 3. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.
 - N. Cabinets:
 1. NEMA 250, Type 1 Type 3R, galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
 2. Hinged door in front cover with flush latch and concealed hinge.
 3. Key latch to match panelboards.
 4. Metal barriers to separate wiring of different systems and voltage.
 5. Accessory feet where required for freestanding equipment.
 6. Nonmetallic cabinets shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- 2.4 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND CABLING
- A. General Requirements for Handholes and Boxes:
 1. Boxes and handholes for use in underground systems shall be designed and identified as defined in NFPA 70, for intended location and application.
 2. Boxes installed in wet areas shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 3. Comply with TIA-569-B.

- B. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel, fiberglass, or a combination of the two.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Armorcast Products Company.
 - b. Quazite: Hubbell Power Systems, Inc.
 2. Standard: Comply with SCTE 77.
 3. Configuration: Designed for flush burial with open bottom unless otherwise indicated.
 4. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
 5. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
 6. Cover Legend: Molded lettering, "COMMUNICATIONS."
 7. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
 8. Handholes 12 Inches Wide by 24 Inches Long and Larger: Have inserts for cable racks and pulling-in irons installed before concrete is poured.
- C. Fiberglass Handholes and Boxes: Molded of fiberglass-reinforced polyester resin, with frame and covers of polymer concrete or fiberglass.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Armorcast Products Company.
 - b. Quazite: Hubbell Power Systems, Inc.
 2. Standard: Comply with SCTE 77.
 3. Color of Frame and Cover: Confirm with the architect & owner.
 4. Configuration: Designed for flush burial with open bottom unless otherwise indicated.
 5. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
 6. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
 7. Cover Legend: Molded lettering, "COMMUNICATIONS."
 8. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
 9. Handholes 12 Inches Wide by 24 Inches Long and Larger: Have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.5 SOURCE QUALITY CONTROL FOR UNDERGROUND ENCLOSURES

- A. Handhole and Pull-Box Prototype Test: Test prototypes of handholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.

1. Tests of materials shall be performed by an independent testing agency.
2. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
3. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

PART 3 - EXECUTION

3.1 PATHWAY APPLICATION

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

1. Exposed Conduit: GRC IMC.
2. Concealed Conduit, Aboveground: GRC IMC EMT.
3. Underground Conduit: RNC, Type EPC-40-PVC, Type EPC-80-PVC, direct buried concrete encased.
4. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.

B. Indoors: Apply pathway products as specified below unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage: EMT or RNC.
2. Exposed, Not Subject to Severe Physical Damage: EMT RNC identified for such use.
3. Exposed and Subject to Severe Physical Damage: GRC. Pathway locations include the following:
 - a. Mechanical rooms.
 - b. Gymnasiums
4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
5. Damp or Wet Locations: GRC IMC.
6. Boxes and Enclosures: NEMA 250 Type 1, except use NEMA 250 Type 4 stainless steel or nonmetallic in institutional and commercial kitchens and damp or wet locations.

C. Minimum Pathway Size: 3/4-inch trade size. Minimum size for optical-fiber cables is 1 inch.

D. Pathway Fittings: Compatible with pathways and suitable for use and location.

1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
3. EMT: Use compression, steel fittings. Comply with NEMA FB 2.10.

- E. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.
- F. Install surface pathways only where indicated on Drawings.
- G. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F.

3.2 INSTALLATION

- A. Comply with NECA 1, NECA 101, and TIA-569-B for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum pathways. Comply with NFPA 70 limitations for types of pathways allowed in specific occupancies and number of floors.
- B. Keep pathways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal pathway runs above water and steam piping.
- C. Complete pathway installation before starting conductor installation.
- D. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.
- E. Arrange stub-ups so curved portions of bends are not visible above finished slab.
- F. Install no more than the equivalent of two 90-degree bends in any pathway run. Support within 12 inches of changes in direction. Utilize long radius ells for all optical-fiber cables.
- G. Conceal conduit and EMT within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
- H. Support conduit within 12 inches of enclosures to which attached.
- I. Pathways Embedded in Slabs:
 - 1. Run conduit larger than 1-inch trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure pathways to reinforcement at maximum 10-foot intervals.
 - 2. Arrange pathways to cross building expansion joints at right angles with expansion fittings.
 - 3. Arrange pathways to keep a minimum of 1 inch of concrete cover in all directions.
 - 4. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.
 - 5. Change from ENT to GRC or IMC before rising above floor.
- J. Stub-ups to Above Recessed Ceilings:
 - 1. Use EMT, IMC, or RMC for pathways.
 - 2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.

- K. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of pathway and fittings before making up joints. Follow compound manufacturer's written instructions.
- L. Coat field-cut threads on PVC-coated pathway with a corrosion-preventing conductive compound prior to assembly.
- M. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install insulated bushings on conduits terminated with locknuts.
- N. Install pathways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.
- O. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.
- P. Cut conduit perpendicular to the length. For conduits of 2-inch trade size and larger, use roll cutter or a guide to ensure cut is straight and perpendicular to the length.
- Q. Install pull wires in empty pathways. Use polypropylene or monofilament plastic line with not less than 200-lbtensile strength. Leave at least 12 inches of slack at each end of pull wire. Cap underground pathways designated as spare above grade alongside pathways in use.
- R. Pathways for Communications Cable: Install pathways, metal and nonmetallic, rigid and flexible, as follows:
 - 1. 3/4-Inch Trade Size and Smaller: Install pathways in maximum lengths of 50 feet.
 - 2. 1-Inch Trade Size and Larger: Install pathways in maximum lengths of 75 feet.
 - 3. Install with a maximum of two 90-degree bends or equivalent for each length of pathway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.
- S. 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.
- T. 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.
- U. Comply with manufacturer's written instructions for solvent welding PVC conduit and fittings.

V. Expansion-Joint Fittings:

1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F, and that has straight-run length that exceeds 25 feet. Install in each run of aboveground RMC and EMT conduit that is located where environmental temperature change may exceed 100 deg F and that has straight-run length that exceeds 100 feet.
2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:
 - a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.
 - b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
 - c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F temperature change.
3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F of temperature change for metal conduits.
4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

W. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.

X. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surface to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.

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

Z. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.

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

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

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

3.3 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:

1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Section 312000 "Earth Moving" for pipe less than 6 inches in nominal diameter.
2. Install backfill as specified in Section 312000 "Earth Moving."
3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Section 312000 "Earth Moving."
4. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through floor unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.
5. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through floor.
 - a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete for a minimum of 12 inches on each side of the coupling.
 - b. For stub-ups at equipment mounted on outdoor concrete bases and where conduits penetrate building foundations, extend steel conduit horizontally a minimum of 60 inches from edge of foundation or equipment base. Install insulated grounding bushings on terminations at equipment.
6. Warning Planks: Bury warning planks approximately 12 inches above direct-buried conduits, but a minimum of 6 inches below grade. Align planks along centerline of conduit.
7. Underground Warning Tape: Comply with requirements in Section 260553 "Identification for Electrical Systems."

3.4 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

- A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.
- B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
- C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch above finished grade.
- D. Install handholes with bottom below frost line, 36" below grade.

- E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in enclosure.
- F. Field cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

3.5 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR COMMUNICATIONS PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 270544 "Sleeves and Sleeve Seals for Communications Pathways and Cabling."

3.6 FIRESTOPPING

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

3.7 PROTECTION

- A. Protect coatings, finishes, and cabinets from damage or deterioration.
 - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
 - 2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 270528

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SECTION 275124 – THEATRE, CHORAL AND BAND ROOM SOUND SYSTEM / FM ASSISTANCE HEARING SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract apply to this Section.

1.2 SUMMARY

- A. This Section includes equipment for amplifying, distributing, and reproducing sound signals for the following areas.
 - 1. Theatre Room, Chorus Room and Band Room
- B. It is a requirement of this specification that The Auditorium Professional Sound Reinforcement System SHALL be electronically modeled using Acoustic Prediction Modeling Software to prove the system will operate correctly and at the highest level of intelligibility achievable for the space. The Acoustic Model is required to be submitted with this contractor's Shop Drawing and Submittal Package to prove the acoustic results of the system before it is deployed.

1.3 DEFINITIONS

- A. Installer(s): Shall refer to the person, persons, or company who or which actually contracts to perform the work specified herein.
- B. Channels: Separate parallel signal paths, from sources to loudspeakers or loudspeaker zones, with separate amplification and switching that permit selection between paths for speaker alternative program signals.
- C. Zone: A separate group of loudspeakers and associated supply wiring that may be arranged for selective switching between different channels.

1.4 SUBMITTALS

- A. Product Data: For each type of equipment.
- B. Shop Drawings: Prior to proceeding with the work:
 - 1. Complete schedule of ALL equipment and materials to be provided for the work.
 - 2. Detail equipment assemblies and indicate dimensions, weights, required clearances, and method of field assembly, components, and location of each field connection.
 - 3. Console layouts.
 - 4. Control panels.

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5. Rack arrangements.
 6. Wiring Diagrams: Detail wiring for power, signal, and control systems and differentiate between manufacturer-installed and field-installed wiring. Identify terminals to facilitate installation, operation, and maintenance. Include a single-line diagram showing cabling interconnection of components.
 7. Each drawing shall have a descriptive title and all sub-parts of each drawing shall be labeled. All drawings shall have the name and locations of the project, Systems Contractor's name in the title block.
 8. Mounting hardware for speaker clusters.
- C. Product Certificates: Signed by manufacturers of equipment certifying that products furnished comply with specified requirements.
- D. Installer Certificates: Signed by manufacturer certifying that installers comply with requirements.
- E. Manufacturer Certificates: Signed by manufacturers certifying that they comply with requirements.
- F. Contractor shall video record the training session(S) and submit (3) copies of DVD's of the sessions for the O&M manuals.
- G. Acoustic Prediction Model: Provide documented complete and comprehensive acoustic models of the system performance proving the correct speaker component selection and insuring the highest intelligibility level achievable for the space. Recommend any acoustic treatments which will improve speech intelligibility to the architect for consideration in the space. Prove the overall system performance and allow the reviewer and/or owner's rep to "listen" to the system operation prior to the space being created.
- 1.5 QUALITY ASSURANCE

- A. Installer Qualifications: An experienced installer who is an authorized representative of equipment manufacturer for both installation and maintenance of equipment required for this Section.
1. Provide documentation demonstrating a minimum of five (5) years previous experience and successfully completing a minimum of five (5) projects of similar size and scope of work.
 2. Provide a list of installations that the Installer has specifically installed for verification by the Owner. Random installations from other vendors and/or Installers shall not be accepted. The Installer, not its employees, must meet these qualifications.
 3. The Installer shall be bondable.
 4. The Installer shall hold a valid Class "A" Contractors License within the Commonwealth of Virginia.
 5. The Installer shall demonstrate to the satisfaction of the Architect/Engineer that he has:
 - a. Adequate plant and equipment to pursue the wok properly and expeditiously.
 - b. Adequate staff and technical experience to implement the work.
 - c. Suitable financial status to meet the obligations of the work.

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- d. Technically capable and factory trained service personnel at a local service facility to provide routine and emergency service for all products used in this project
- 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.
- C. Comply with NFPA 70.
- D. Comply with UL 50.

1.6 OCCUPANCY ADJUSTMENTS

- A. On-Site Assistance: Engage a factory-authorized service representative to provide on-site maintenance in adjusting sound levels, resetting transformer taps, and adjusting controls and cleaning of source devices to meet occupancy conditions. Provide two (2) on-site “preventive maintenance” service calls within one year spaced six (6) months apart after Substantial Completion.
- B. The Installer shall be prepared to offer a service contract for the system after the warranty period.

PART 2 - PRODUCTS

2.1 EQUIPMENT

- A. Coordinate features to form an integrated system. Match components and interconnections for optimum performance of specified functions.
- B. Equipment: Modular type, using solid-state components, fully rated for continuous duty, unless otherwise indicated. Select equipment for normal operation on input power usually supplied at 110 to 130 V, 60 Hz.

2.2 SYSTEM PROCESSORS

- A. Drama Room, Chorus Room and Band Room:
 - 1. Main System processor shall provide basic mixing functions for “Simple” system operation, and shall provide all system equalization, protection, anti-feedback and alignment of signals to be sent to the amplifiers.
 - a. Basis of Design: Biamp AudiaFlex, configured as required.

2.3 DIGITAL MIXING SYSTEM

- A. Drama Room, Chorus Room and Band Room:
 - 1. Digital Mixing Console (Provide one):

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- a. Basis of Design: Behringer X32 series with:
- b. Behringer S32 Digital Snake System and,
- c. Behringer S16 Digital Snake with rack mounting hardware.

2.4 WIRELESS MICROPHONE AND REMOTE ANTENNA DISTRIBUTION

1. Drama Room, Chorus Room and Band Room:
 - a. Basis of Design: Shure UA-844+SWD with,
 - b. Shure UA-8 Series Antennas and,
 - c. Shure UA-834WB Remote Preamplifiers.
2. Wireless Microphone Systems (Provide a total of two):
 - a. Basis of Design: Shure ULX4 UHF receivers with,
 - b. One each Shure ULX2/58 Handheld Transmitter, and,
 - c. One each Shure ULX1 Belt pack Transmitter with;
 - d. One each Shure WL51B Miniature Lavalier Microphone.

2.5 POWER AMPLIFIERS

- A. Drama Room, Chorus Room and Band Room:
 1. Type 1 Amplifiers:
 - a. Basis of Design: Bose Powershare 602.
 - b. Function: Stage Speaker Systems amplifiers, House Speaker amplifier.
 - c. Provide four (4)
- B. Mounting:
 1. Mount in equipment racks as indicated.

2.6 LOUDSPEAKERS

- A. Drama Room, Chorus Room and Band Room:
 1. Stage Left, Center, Right Speaker Systems:
 - a. Basis of Design: Bose 402 (provide three) with,
 - b. Bose MB-4 subwoofers (provide three)
 - c. Subwoofers to be mounted above main speaker cabinet.
 - d. Coordinate speaker locations for best coverage.
 2. House Loudspeakers:
 - a. Basis of Design: Bose DS-100SE (provide four)
 - b. Loudspeakers to be mounted on Ceiling.
 - c. Coordinate speaker locations for best coverage.

2.7 COMPONENTS

- A. Microphone(s): Comply with EIA SE-105.

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1. Type: Dynamic, with cardioid polar characteristic, vocal use w/ switch.
 - a. Basis of Design: Shure SM58S (provide four).
 2. Type: Dynamic, with cardioid polar characteristic, instrument use.
 - a. Basis of Design: Shure SM57 (provide two).
- B. Microphone Stands:
1. Type: Floor Stand, vocal use.
 - a. Basis of Design: Atlas MS-12CE (provide six).
 2. Type: Floor Boom Stand, instrument use.
 - a. Basis of Design: Atlas SB-36W (provide two).
 3. Type: Desk Stand, desk or low instrument use.
 - a. Basis of Design: Atlas DS-7E (provide two).
- C. Interface Boxes:
1. Type: Direct Boxes, allowing high impedance input from any piece of stage equipment (keyboard, guitar amplifier, CD player, etc.) to the low impedance input of the sound system:
 - a. Basis of Design: Proco DB-1 (provide one).
 2. Type: Direct Boxes, allowing high impedance input from laptop computers or other equipment with a 1/8" TRS Connector to the low impedance input of the sound system:
 - b. Basis of Design: Rapco LTI-100 (provide one).
- D. Microphone Cables.
1. Rubber covered with braided shield construction using Belden 8412 cable.
 - a. Basis of Design: Rapco SP Series.
 - b. Provide 10 each 25 foot cables.
 - c. Provide 5 each 50 foot cables.
 - d. Provide 2 each 75 foot cables.
- E. Cable and Conductors: Jacketed, twisted-pair and twisted-multi-pair, un-tinned, solid-copper conductors.
1. Insulation for Wire in Conduit: Thermoplastic, not less than 1/32 inch thick.
 2. Microphone Cables: Neoprene jacketed, not less than 2/64 inch thick over shield with filled interstices. Shield No. 34 AWG tinned, soft-copper strands formed into a braid or approved equivalent foil. Shielding coverage on conductors is not less than 60 percent.

2.8 HEARING ASSISTANCE SYSTEM

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- A. The system shall transmit the program material used within the Individual Sound Systems for the “Commons”.
1. Transmitter basis of design: Listen Technologies LT-800-072.
 - a. The system shall operate within the 72-76 MHz band allocated for hearing assistance transmission. The transmitter shall broadcast up to 300 feet with a whip antenna.
 - b. The unit shall accept both Low-Z and High-Z line inputs and frequency-synthesized with phase locked loop tuning
 - c. Provide one, with rack mounting hardware.
 2. Receiver basis of design: Listen Technologies LR-4200-072.
 - a. The receivers shall be compact agile frequency FM receivers complete with volume/on-off control. The unit shall operate on a standard 9-volt battery.
 - b. The receivers shall be able to “Lock” the received frequency to prevent tampering.
 - c. Provide eight.
 3. Provide the following Hearing Assistance components:
 - a. Remote dipole antenna: Listen Technologies LA-401 (Provide one).
 - b. Ear Speakers: Listen Technologies LA-164 (Provide four).
 - c. 4 Space Charging and Storage Case: Listen Technologies LA 317 (Provide one).
 - d. Provide NiMH Rechargeable batteries as required for all receivers.

2.9 SOUND SYSTEM RACK

- A. Sound System Rack shall be wall mounted in the storage room. Panel space openings shall be sized to match equipment with 20% spare capacity. Enclosures shall be equipped with convenient and useful provisions for custom cabinet mounting, wire management, equipment mounting, and structural support. Cabinet shall be finished in black epoxy.
1. Equipment Rack basis of design: Atlas WMA Series, size based on selected equipment.
 - a. Rack shall have appropriate available space.
 - b. Rack shall have 19 inches of useable depth.
 - c. Provide a power control system to allow for proper turn-on and turn-off sequencing. Sequencer shall allow for different sequences based on the initiating turn-on location.
 - d. Provide Surge suppression for the processing and other sensitive electronics, Basis of design: Surge-X.
 - e. Provide lockable vented front door.
 - f. Provide thermostatically controlled ventilation. Vent fan(s) shall be arranged such that the hot air exhausts from the top of the rack.

B. EXECUTION

2.10 INSTALLATION

- A. Install equipment to comply with manufacturer's written instructions.
- B. Wiring Method: Install wiring in raceway except within consoles, desks, and counters. Conceal cable and raceway except in unfinished spaces.
- C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess. Use lacing bars in cabinets.
- D. Control-Circuit Wiring: Install number and size of conductors as recommended by system manufacturer for control functions indicated.
- E. Separation of Wires: Separate speaker-microphone, line-level, speaker-level, and power wiring runs. Install in separate raceways or, where exposed or in same enclosure, separate conductors at least 12 inches (300 mm) for speaker microphones and adjacent parallel power and telephone wiring. Separate other intercommunication equipment conductors as recommended by equipment manufacturer.
- F. Splices, Taps, and Terminations: Make splices, taps, and terminations on numbered terminal strips in junction, pull, and outlet boxes, terminal cabinets and equipment enclosures.
- G. Match input and output impedances and signal levels at signal interfaces. Provide matching networks where required.
- H. Identification of Conductors and Cables: Color-code conductors and apply wire and cable marking tape to designate wires and cables to identify media in coordination with system wiring diagrams.
- I. Wall-Mounting Outlets: Flush mounted.
- J. Floor-Mounting Outlets: Conceal in floor and install cable nozzles through outlet covers. Secure outlet covers in place. Trim with carpet in carpeted areas.
- K. Conductor Sizing: Unless otherwise indicated, size speaker circuit conductors from racks to loudspeaker outlets not smaller than No. 14 AWG and conductors from microphone receptacles to amplifiers not smaller than No. 22 AWG.
- L. Line Matching Transformer Connections: Make initial connections using tap settings recommend by manufacturer.

2.11 GROUNDING

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- A. Ground cable shields and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
- B. Signal Ground Terminal: Locate at main equipment cabinet. Isolate from power system and equipment grounding.

2.12 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installations, including connections. Report results in writing.
- B. Operational Test: Perform tests that include originating program and page material at microphone outlets, preamplifier program inputs, and other inputs. Verify proper routing and volume levels and freedom from noise and distortion.
- C. Signal-to-Noise Ratio Test: Measure the ratio of signal to noise of complete system at normal gain settings, using the following procedure:
 - 1. Disconnect a microphone at the connector or jack closest to it and replace it in the circuit with a signal generator using a 1000-Hz signal. Replace all other microphones at corresponding connectors with dummy loads, each equal in impedance to microphone it replaces. Measure the ratio of signal to noise.
 - 2. Repeat test for each separately controlled zone of loudspeakers.
 - 3. Minimum acceptance ratio is 50 dB.
- D. Distortion Test: Measure distortion at normal gain settings and rated power. Feed signals at frequencies of 50, 200, 400, 1000, 3000, 8000, and 12,000 Hz into each preamplifier channel. For each frequency, measure the distortion in the amplifier outputs. Maximum acceptable distortion at any frequency is 3 percent total harmonics.
- E. Power Output Test: Measure electrical power outputs of each amplifier at normal gain setting at 50, 1000, and 12,000 Hz. Maximum variation in power output at these frequencies must not exceed plus or minus 1 dB.
- F. Signal Ground Test: Measure and report ground resistance at public address equipment signal ground. Comply with testing requirements specified in Division 26 Section "Grounding and Bonding for Electrical Systems."
- G. Retesting: Correct deficiencies, revising tap settings of speaker-line matching transformers where necessary to optimize volume and uniformity of sound levels, and retest. Prepare written record tests.
- H. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified. Prepare a list of final tap settings of paging speaker-line matching transformers.

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- I. Schedule tests with at least seven days' advance notice of test performance.
- J. Field Test Reports: Indicate and interpret test results for compliance with performance requirements. Include record of final speaker-line matching transformer-tap settings, and signal ground-resistance measurement certified by Installer.
- K. Maintenance Data: For equipment to include in maintenance manuals specified in Division 1.
- L. Record Drawings: Prior to final acceptance, provide three (3) complete sets of drawings indicating all cable numbers and construction details in accordance with the actual system installation. Revise all shop drawings to represent actual installation conditions. These Record Drawings will be used during "Final Acceptance Testing".

2.13 FINAL ACCEPTANCE TESTING

- A. The Final Acceptance Testing shall be provided by the Owner or the Owners agent. Coordinate this period so that free access, work lighting and electrical power are available on the site.
- B. Be prepared to verify the performance of any portion of the installation by demonstration, listening and viewing test, and instrumented measurements. Make additional adjustments within the scope of work and which are deemed necessary by the Owner because of the acceptance test.

2.14 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain equipment as specified below:
 - 1. Train Owners maintenance personnel on programming equipment for starting up and shutting down, troubleshooting, servicing, and maintaining equipment.
 - 2. Review data in maintenance manuals. Refer to Division 1 Section "Project Closeout."
 - 3. Schedule training with Owner, through Architect, with at least seven days' advance notice.

END OF SECTION 275124

SECTION 280500 - COMMON WORK RESULTS FOR ELECTRONIC SAFETY AND SECURITY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Electronic safety equipment coordination and installation.
 - 2. Sleeves for raceways and cables.
 - 3. Sleeve seals.
 - 4. Grout.
 - 5. Common electronic safety installation requirements.

1.3 DEFINITIONS

- A. EPDM: Ethylene-propylene-diene terpolymer rubber.
- B. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

- A. Product Data: For sleeve seals.

1.5 COORDINATION

- A. Coordinate arrangement, mounting, and support of electronic safety equipment:
 - 1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
 - 2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
 - 3. To allow right of way for piping and conduit installed at required slope.
 - 4. So connecting raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.
- B. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

- C. Coordinate location of access panels and doors for electronic safety and security items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08 Section "Access Doors and Frames."
- D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

PART 2 - PRODUCTS

2.1 SLEEVES FOR RACEWAYS AND 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. Sleeves for Rectangular Openings: Galvanized sheet steel.
 - 1. Minimum Metal Thickness:
 - a. For sleeve cross-section rectangle perimeter less than 50 inches and no side more than 16 inches, thickness shall be 0.052 inch.
 - b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches and 1 or more sides equal to, or more than, 16 inches, thickness shall be 0.138 inch.

2.2 SLEEVE SEALS

- A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
 - 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. Advance Products & Systems, Inc.
 - b. Calpico, Inc.
 - c. Metraflex Co.
 - d. Pipeline Seal and Insulator, Inc.
 - 2. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
 - 3. Pressure Plates: Carbon steel. Include two for each sealing element.
 - 4. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.3 GROUT

- A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, non-staining, mixed with water to consistency suitable for application and a 30-minute working time.

PART 3 - EXECUTION

3.1 COMMON REQUIREMENTS FOR ELECTRONIC SAFETY INSTALLATION

- A. Comply with NECA 1.
- B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
- C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.
- D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electronic safety and security equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.
- E. Right of Way: Give to piping systems installed at a required slope.

3.2 SLEEVE INSTALLATION FOR ELECTRONIC SAFETY PENETRATIONS

- A. Electronic safety and security penetrations occur when raceways, pathways, cables, wireways, or cable trays penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.
- 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. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
- D. 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.
- E. Cut sleeves to length for mounting flush with both surfaces of walls.
- F. Extend sleeves installed in floors 2 inches above finished floor level.
- G. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable, unless indicated otherwise.

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- H. Seal space outside of sleeves with grout for penetrations of concrete and masonry
 - 1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.
- I. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants."
- J. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping."
- K. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.
- L. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- M. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing mechanical sleeve seals.

3.3 SLEEVE-SEAL INSTALLATION

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

3.4 FIRESTOPPING

- A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electronic safety and security installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

END OF SECTION 280500

SECTION 280528 - PATHWAYS FOR ELECTRONIC SECURITY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Provisions of the Contract and of the Contract Documents apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Metal conduits, tubing, and fittings.
 - 2. Nonmetallic conduits, tubing, and fittings.
 - 3. Optical-fiber-cable pathways and fittings.
 - 4. Surface pathways.
 - 5. Boxes, enclosures, and cabinets.
 - 6. Handholes and boxes for exterior underground cabling.

1.3 ACTION SUBMITTALS

- A. Product Data: For surface pathways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.
- B. Shop Drawings: For custom enclosures and cabinets.

PART 2 - PRODUCTS

2.1 METAL CONDUITS, TUBING, AND FITTINGS

- A. General Requirements for Metal Conduits and Fittings:
 - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 2. Comply with TIA-569-B.
- B. GRC: Comply with ANSI C80.1 and UL 6.
- C. ARC: Comply with ANSI C80.5 and UL 6A.
- D. EMT: Comply with ANSI C80.3 and UL 797.
- E. FMC: Comply with UL 1; zinc-coated steel or aluminum.
- F. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.
 - 1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886 and NFPA 70.
 - 2. Fittings for EMT:
 - a. Material: Steel or die cast.
 - b. Type: Setscrew or compression.
 - 3. Expansion Fittings: PVC or steel to match conduit type, complying with UL-467, rated for environmental conditions where installed, and including flexible external bonding jumper.
- G. Joint Compound for GRC or ARC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 NONMETALLIC CONDUITS, TUBING, AND FITTINGS

- A. General Requirements for Nonmetallic Conduits and Fittings:
 - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 2. Comply with TIA-569-B.
- B. ENT: Comply with NEMA TC 13 and UL 1653.
- C. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.
- D. Continuous HDPE: Comply with UL 651B.
- E. Fittings for ENT and RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.

2.3 OPTICAL-FIBER-CABLE PATHWAYS AND FITTINGS

- A. Description: Comply with UL 2024; flexible-type pathway, approved for plenum riser or general-use installation unless otherwise indicated.
 - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 2. Comply with TIA-569-B.

2.4 SURFACE PATHWAYS

- A. General Requirements for Surface Pathways:
 - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 2. Comply with TIA-569-B.
- B. Surface Metal Pathways: Galvanized steel with snap-on covers complying with UL 5. Manufacturer's standard enamel finish.
- C. Surface Nonmetallic Pathways: Two- or three-piece construction, complying with UL 5A, and manufactured of rigid PVC with texture and color selected by Architect from manufacturer's standard colors. Product shall comply with UL-94 V-0 requirements for self-extinguishing characteristics.

2.5 BOXES, ENCLOSURES, AND CABINETS

- A. General Requirements for Boxes, Enclosures, and Cabinets:
 - 1. Comply with TIA-569-B.
 - 2. All enclosures, cabinets, housings, boxes, and fittings having hinged doors or removable covers must be able to be locked or secured with tamper resistant security fasteners.
 - 3. Boxes, enclosures and cabinets installed in wet locations shall be listed for use in wet locations.
- B. Sheet-Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.
- C. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.
- D. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
- E. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

- F. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, cast aluminum with gasketed cover.
- G. Device Box Dimensions: 4 inches square by 2-1/8 inches deep.
- H. Gangable boxes are prohibited.
- I. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.
- J. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1 with continuous-hinge cover with flush latch unless otherwise indicated.
 - 1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
 - 2. Nonmetallic Enclosures: Plastic or fiberglass.
 - 3. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.
- K. Cabinets:
 - 1. NEMA 250, Type 1, galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
 - 2. Hinged door in front cover with flush latch and concealed hinge.
 - 3. Key latch to match panelboards.
 - 4. Metal barriers to separate wiring of different systems and voltage.
 - 5. Accessory feet where required for freestanding equipment.
 - 6. Nonmetallic cabinets shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.6 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND CABLING

- A. General Requirements for Handholes and Boxes:
 - 1. Boxes and handholes for use in underground systems shall be designed and identified as defined in NFPA 70, for intended location and application.
 - 2. Boxes installed in wet areas shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 3. Comply with TIA-569-B.
- B. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel, fiberglass, or a combination of the two.
 - 1. Standard: Comply with SCTE 77.
 - 2. Configuration: Designed for flush burial with integral closed bottom unless otherwise indicated.
 - 3. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
 - 4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
 - 5. Cover Legend: Molded lettering, "ELECTRIC" or "COMMUNICATIONS."
- C. Fiberglass Handholes and Boxes: Molded of fiberglass-reinforced polyester resin, with covers of polymer concrete.
 - 1. Standard: Comply with SCTE 77.
 - 2. Color of Frame and Cover: Gray.
 - 3. Configuration: Designed for flush burial with integral closed bottom unless otherwise indicated.
 - 4. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
 - 5. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.

6. Cover Legend: Molded lettering, "ELECTRIC" or "COMMUNICATIONS."

PART 3 - EXECUTION

3.1 PATHWAY APPLICATION

- A. Outdoors: Apply pathway products as specified below unless otherwise indicated:
1. Exposed Conduit: GRC.
 2. Concealed Conduit, Aboveground: GRC.
 3. Underground Conduit: RNC, Type EPC-80-PVC, concrete encased.
 4. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.
- B. Indoors: Apply pathway products as specified below unless otherwise indicated:
1. Exposed, Not Subject to Physical Damage: EMT.
 2. Exposed, Not Subject to Severe Physical Damage: EMT.
 3. Exposed and Subject to Severe Physical Damage: GRC.
 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
 6. Damp or Wet Locations: GRC.
 7. Pathways for Optical-Fiber or Communications Cable in Spaces Used for Environmental Air: Plenum-type, optical-fiber-cable pathway Plenum-type, communications-cable pathway EMT.
 8. Pathways for Optical-Fiber or Communications-Cable Risers in Vertical Shafts: Riser-type, optical-fiber-cable pathway Riser-type, communications-cable pathway EMT.
 9. Pathways for Concealed General-Purpose Distribution of Optical-Fiber or Communications Cable: General-use, optical-fiber-cable pathway Riser-type, optical-fiber-cable pathway Plenum-type, optical-fiber-cable pathway General-use, communications-cable pathway Riser-type, communications-cable pathway Plenum-type, communications-cable pathway EMT.
 10. Boxes and Enclosures: NEMA 250 Type 1, except use NEMA 250, Type 4 stainless steel in damp or wet locations.
- C. Minimum Pathway Size: 3/4-inch trade size. Minimum size for optical-fiber cables is 1 inch.
- D. Pathway Fittings: Compatible with pathways and suitable for use and location.
1. Rigid Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
 2. EMT: Use setscrew or compression, steel fittings. Comply with NEMA FB 2.10.
 3. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.
- E. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.
- F. Install surface pathways only where indicated on Drawings.
- G. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F.

3.2 INSTALLATION

- A. Comply with NECA 1, NECA 101, and TIA-569-B for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum

pathways. Comply with NFPA 70 limitations for types of pathways allowed in specific occupancies and number of floors.

- B. Keep pathways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal pathway runs above water and steam piping.
- C. Comply with requirements in Division 26 Section "Hangers and Supports for Electrical Systems" for hangers and supports.
- D. Comply with requirements in Division 26 Section "Underground Ducts and Raceways for Electrical Systems" for underground duct installation.
- E. Install no more than the equivalent of three 90-degree bends in any conduit run except for communications wiring conduits for which only two 90-degree bends are allowed. Support within 12 inches of changes in direction.
- F. Conceal conduit and EMT within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
- G. Pathways Embedded in Slabs:
 - 1. Run conduit larger than 1-inch trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure pathways to reinforcement at maximum 10-foot intervals.
 - 2. Arrange pathways to cross building expansion joints at right angles with expansion fittings.
 - 3. Arrange pathways to keep a minimum of 2 inches of concrete cover in all directions.
 - 4. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.
- H. Stub-ups to Above Recessed Ceilings:
 - 1. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.
- I. Coat field-cut threads on PVC-coated pathway with a corrosion-preventing conductive compound prior to assembly.
- J. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install insulated bushings on conduits terminated with locknuts.
- K. Install pathways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.
- L. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to conduit assembly to assure a continuous ground path.
- M. Spare Pathways: Install pull wires in empty pathways. Cap underground pathways designated as spare above grade alongside pathways in use.
- N. Surface Pathways:
 - 1. Install surface pathway for surface electrical outlet boxes only where indicated on Drawings.
- O. Pathways for Optical-Fiber and Communications Cable: Install pathways as follows:
 - 1. 3/4-Inch Trade Size and Smaller: Install pathways in maximum lengths of 50 feet.
 - 2. 1-Inch Trade Size and Larger: Install pathways in maximum lengths of 75 feet.
 - 3. Install with a maximum of two 90-degree bends or equivalent for each length of pathway unless Drawings show stricter requirements.

- P. Install pathway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound.
 - Q. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all pathways at the following points:
 - 1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
 - 2. Where an underground service pathway enters a building or structure.
 - 3. Where otherwise required by NFPA 70.
 - R. Expansion-Joint Fittings:
 - 1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F, and that has straight-run length that exceeds 25 feet. Install in each run of aboveground RMC and EMT that is located where environmental temperature change may exceed 100 deg F and that has straight-run length that exceeds 100 feet.
 - 2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:
 - a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.
 - b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
 - c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F temperature change.
 - d. Attics: 135 deg F temperature change.
 - 3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F of temperature change for metal conduits.
 - 4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
 - 5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.
 - S. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72 inches of flexible conduit for luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
 - T. Mount boxes at heights indicated on Drawings according to ADA requirements. Install boxes with height measured to top of box unless otherwise indicated.
 - U. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.
- 3.3 INSTALLATION OF UNDERGROUND CONDUIT
- A. Direct-Buried Conduit:
 - 1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Division 31 Section "Earthwork" for pipe less than 6 inches in nominal diameter.
 - 2. Install backfill as specified in Division 31 Section "Earthwork."
 - 3. After installing conduit, backfill and compact. After placing controlled backfill to within 12 inches of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Division 31 Section "Earthwork."

4. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through floor.
 - a. Couple steel conduits to ducts with adapters designed for this purpose.
 - b. For stub-ups at equipment mounted on outdoor concrete bases and where conduits penetrate building foundations, extend steel conduit horizontally a minimum of 60 inches from edge of foundation or equipment base. Install insulated grounding bushings on terminations at equipment.
5. Underground Warning Tape: Comply with requirements in Division 26 Section "Identification for Electrical Systems."

3.4 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

- A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.
- B. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch above finished grade.
- C. Install handholes with bottom below frost line, below grade.
- D. Field cut openings for conduits according to enclosure manufacturer's written instructions.

3.5 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRONIC SECURITY PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Division 28 Section "Common Work Results for Electronic Safety and Security."

3.6 FIRESTOPPING

- A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Division 07 Section "Penetration Firestopping."

3.7 PROTECTION

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

END OF SECTION 280528

SECTION 283111 - DIGITAL, ADDRESSABLE FIRE-ALARM SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Manual fire-alarm boxes.
 - 2. System smoke detectors.
 - 3. Notification appliances.
 - 4. Addressable interface device.

1.3 DESCRIPTION

- A. Provide an expansion of the existing fire alarm system. The existing fire alarm system in the first floor shall be extended into the addition. Provide extender panels where required. Provide a dedicated 120volt circuit to extender panels. Provide a smoke detector above each extender panel.

1.4 DEFINITIONS

- A. EMT: Electrical Metallic Tubing.
- B. FACP: Fire Alarm Control Panel.
- C. HLI: High Level Interface.
- D. NICET: National Institute for Certification in Engineering Technologies.
- E. PC: Personal computer.

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product, including furnished options and accessories.
 - 1. Include construction details, material descriptions, dimensions, profiles, and finishes.
 - 2. Include rated capacities, operating characteristics, and electrical characteristics.

B. Shop Drawings: For fire-alarm system.

1. Comply with recommendations and requirements in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
2. Include plans, elevations, sections, details, and attachments to other work.
3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and locations. Indicate conductor sizes, indicate termination locations and requirements, and distinguish between factory and field wiring.
4. Detail assembly and support requirements.
5. Include voltage drop calculations for notification-appliance circuits.
6. Include battery-size calculations.
7. Include input/output matrix.
8. Include statement from manufacturer that all equipment and components have been tested as a system and meet all requirements in this Specification and in NFPA 72.
9. Include performance parameters and installation details for each detector.
10. Verify that each duct detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
11. Provide program report showing that air-sampling detector pipe layout balances pneumatically within the airflow range of the air-sampling detector.
12. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale; coordinate location of duct smoke detectors and access to them.
 - a. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators.
 - b. Show field wiring required for HVAC unit shutdown on alarm.
 - c. Locate detectors according to manufacturer's written recommendations.
13. Include floor plans to indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits and point-to-point wiring diagrams.

C. General Submittal Requirements:

1. Submittals shall be approved by the architect prior to submission to authorities having jurisdiction.
2. Shop Drawings shall be prepared by persons with the following qualifications:
 - a. Trained and certified by manufacturer in fire-alarm system design.
 - b. NICET-certified, fire-alarm technician; Level III minimum.
 - c. Licensed or certified by authorities having jurisdiction.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Field quality-control reports.

1.7 Sample Warranty: For special warranty.

1.8 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following and deliver copies to authorities having jurisdiction:
 - a. Comply with the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
 - b. Provide "Fire Alarm System Record of Completion Documents" according to the "Completion Documents" Article in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
 - c. Complete wiring diagrams showing connections between all devices and equipment. Each conductor shall be numbered at every junction point with indication of origination and termination points.
 - d. Riser diagram.
 - e. Device addresses.
 - f. Record copy of site-specific software.
 - g. Provide "Inspection and Testing Form" according to the "Inspection, Testing and Maintenance" chapter in NFPA 72, and include the following:
 - 1) Equipment tested.
 - 2) Frequency of testing of installed components.
 - 3) Frequency of inspection of installed components.
 - 4) Requirements and recommendations related to results of maintenance.
 - 5) Manufacturer's user training manuals.
 - h. Manufacturer's required maintenance related to system warranty requirements.
 - i. Abbreviated operating instructions for mounting at fire-alarm control unit and each annunciator unit.

1.9 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Lamps for Strobe Units: Quantity equal to 10 percent of amount installed, but no fewer than one unit.
2. Smoke Detectors: Quantity equal to 10 percent of amount of each type installed, but no fewer than one unit of each type.
3. Detector Bases: Quantity equal to two percent of amount of each type installed, but no fewer than one unit of each type.
4. Keys and Tools: One extra set for access to locked or tamperproofed components.
5. Audible and Visual Notification Appliances: ten of each type installed.

6. Fuses: Two of each type installed in the system. Provide in a box or cabinet with compartments marked with fuse types and sizes.

1.10 QUALITY ASSURANCE

- A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.
- B. Installer Qualifications: Installation shall be by personnel certified by NICET as fire-alarm Level III technician.
- C. NFPA Certification: Obtain certification according to NFPA 72 by an NRTL (nationally recognized testing laboratory).

1.11 PROJECT CONDITIONS

- A. Perform a full test of the existing system prior to starting work. Document any equipment or components not functioning as designed.
- B. Use of Devices during Construction: Protect devices during construction unless devices are placed in service to protect the facility during construction.

1.12 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace fire-alarm system equipment and components that fail in materials or workmanship within specified warranty period.
 1. Warranty Extent: All equipment and components not covered in the Maintenance Service Agreement.
 2. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Source Limitations for Fire-Alarm System and Components: Components shall be compatible with, and operate as an extension of, existing system. Provide system manufacturer's certification that all components provided have been tested as, and will operate as, a system.
- B. Noncoded, UL-certified addressable system, with multiplexed signal transmission and horn/strobe evacuation.
- C. Automatic sensitivity control of certain smoke detectors.
- D. All components provided shall be listed for use with the selected system.

- E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 SYSTEMS OPERATIONAL DESCRIPTION

- A. Fire-alarm signal initiation shall be by one or more of the following devices:
 - 1. Manual stations.
 - 2. Smoke detectors.
 - 3. Duct smoke detectors.
 - 4. Automatic sprinkler system water flow.
- B. Fire-alarm signal shall initiate the following actions:
 - 1. Continuously operate alarm notification appliances.
 - 2. Identify alarm and specific initiating device at fire-alarm control unit.
 - 3. Transmit an alarm signal to the remote alarm receiving station.
 - 4. Unlock electric door locks in designated egress paths.
 - 5. Switch heating, ventilating, and air-conditioning equipment controls to fire-alarm mode.
 - 6. Close smoke dampers in air ducts of designated air-conditioning duct systems.
 - 7. Recall elevators to primary or alternate recall floors.
 - 8. Activate elevator power shunt trip.
 - 9. Activate emergency shutoffs for gas and fuel supplies.
 - 10. Record events in the system memory.
- C. Supervisory signal initiation shall be by one or more of the following devices and actions:
 - 1. Valve supervisory switch.
 - 2. Elevator shunt-trip supervision.
- D. System trouble signal initiation shall be by one or more of the following devices and actions:
 - 1. Open circuits, shorts, and grounds in designated circuits.
 - 2. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
 - 3. Loss of communication with any addressable sensor, input module, relay, control module, remote annunciator, printer interface, or Ethernet module.
 - 4. Loss of primary power at fire-alarm control unit.
 - 5. Ground or a single break in internal circuits of fire-alarm control unit.
 - 6. Abnormal ac voltage at fire-alarm control unit.
 - 7. Break in standby battery circuitry.
 - 8. Failure of battery charging.
 - 9. Abnormal position of any switch at fire-alarm control unit or annunciator.
- E. System Supervisory Signal Actions:
 - 1. Initiate notification appliances.

2. Identify specific device initiating the event at fire-alarm control unit and remote annunciators.
3. After a time delay of 60 seconds, transmit a trouble or supervisory signal to the remote alarm receiving station.
4. Transmit system status to building management system.

2.3 MANUAL FIRE-ALARM BOXES

- 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. Gamewell - FCI by Honeywell.
 2. Notifier.
 3. SimplexGrinnell LP.
- B. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes shall be finished in red with molded, raised-letter operating instructions in contrasting color; shall show visible indication of operation; and shall be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.
1. Double-action mechanism requiring two actions to initiate an alarm, pull-lever type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.
 2. Station Reset: Key- or wrench-operated switch.

2.4 SYSTEM SMOKE DETECTORS

- 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. Gamewell - FCI by Honeywell.
 2. Notifier.
 3. SimplexGrinnell LP.
- B. General Requirements for System Smoke Detectors:
1. Comply with UL 268; operating at 24-V dc, nominal.
 2. Detectors shall be two-wire type.
 3. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
 4. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
 5. Integral Visual-Indicating Light: LED type, indicating detector has operated and power-on status.
 6. Remote Control: Unless otherwise indicated, detectors shall be digital-addressable type, individually monitored at fire-alarm control unit for calibration, sensitivity, and alarm condition and individually adjustable for sensitivity by fire-alarm control unit.

- a. Multiple levels of detection sensitivity for each sensor.
- b. Sensitivity levels based on time of day.

C. Photoelectric Smoke Detectors:

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
 - a. Primary status.
 - b. Device type.
 - c. Present average value.
 - d. Present sensitivity selected.
 - e. Sensor range (normal, dirty, etc.).

D. Duct Smoke Detectors: Photoelectric type complying with UL 268A.

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
 - a. Primary status.
 - b. Device type.
 - c. Present average value.
 - d. Present sensitivity selected.
 - e. Sensor range (normal, dirty, etc.).
3. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector for smoke detection in HVAC system ducts.
4. Each sensor shall have multiple levels of detection sensitivity.
5. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
6. Relay Fan Shutdown: Fully programmable relay rated to interrupt fan motor-control circuit.

2.5 NOTIFICATION APPLIANCES

- 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. Federal Signal Corporation.
 2. Siemens Industry, Inc.; Fire Safety Division.
 3. SimplexGrinnell LP.

- B. General Requirements for Notification Appliances: Individually addressed, connected to a signaling-line circuit, equipped for mounting as indicated, and with screw terminals for system connections.
 - 1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated, and with screw terminals for system connections.
- C. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Comply with UL 464. Horns shall produce a sound-pressure level of 90 dBA, measured 10 feet from the horn, using the coded signal prescribed in UL 464 test protocol.
- D. Visible Notification Appliances: Xenon strobe lights complying with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch- high letters on the lens.
 - 1. Rated Light Output:
 - a. 15/30/75/110 cd, selectable in the field.
 - 2. Mounting: Wall mounted unless otherwise indicated.
 - 3. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.
 - 4. Flashing shall be in a temporal pattern, synchronized with other units.
 - 5. Strobe Leads: Factory connected to screw terminals.
 - 6. Mounting Faceplate: Factory finished, white.
- E. Voice/Tone Notification Appliances:
 - 1. Comply with UL 1480.

2.6 MAGNETIC DOOR HOLDERS

- A. Description: Units are equipped for wall or floor mounting as indicated and are complete with matching doorplate.
 - 1. Electromagnets: Require no more than 3 W to develop 25-lbf holding force.
 - 2. Wall-Mounted Units: Flush mounted unless otherwise indicated.
 - 3. Provide control module for door release.
 - 4. Rating: 120-V ac.
- B. Material and Finish: Match door hardware.

2.7 ADDRESSABLE INTERFACE DEVICE

- A. General:
 - 1. Include address-setting means on the module.

2. Store an internal identifying code for control panel use to identify the module type.
 3. Listed for controlling HVAC fan motor controllers.
- B. Monitor Module: Microelectronic module providing a system address for alarm-initiating devices for wired applications with normally open contacts.
- C. Integral Relay: Capable of providing a direct signal to elevator controller to initiate elevator recall and to circuit-breaker shunt trip for power shutdown.
1. Allow the control panel to switch the relay contacts on command.
 2. Have a minimum of two normally open and two normally closed contacts available for field wiring.
- D. Control Module:
1. Operate notification devices.
 2. Operate solenoids for use in sprinkler service.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions for compliance with requirements for ventilation, temperature, humidity, and other conditions affecting performance of the Work.
1. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment and wiring are installed, before installation begins.
- B. Examine roughing-in for electrical connections to verify actual locations of connections before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PROGRAMMING

- A. Program the existing fire alarm system to activate the existing exterior audible/visible alarm upon activation of the new wet pipe sprinkler system flow switch and upon activation of the new dry pipe sprinkler system alarm pressure switch.

3.3 EQUIPMENT INSTALLATION

- A. Comply with NFPA 72, NFPA 101, and requirements of authorities having jurisdiction for installation and testing of fire-alarm equipment. Install all electrical wiring to comply with requirements in NFPA 70 including, but not limited to, Article 760, "Fire Alarm Systems."

1. Devices placed in service before all other trades have completed cleanup shall be replaced.
 2. Devices installed but not yet placed in service shall be protected from construction dust, debris, dirt, moisture, and damage according to manufacturer's written storage instructions.
- B. Connecting to Existing Equipment: Verify that existing fire-alarm system is operational before making changes or connections.
1. Connect new equipment to existing control panel in existing part of the building.
 2. Connect new equipment to existing monitoring equipment at the supervising station.
 3. Expand, modify, and supplement existing monitoring equipment as necessary to extend existing monitoring functions to the new points. New components shall be capable of merging with existing configuration without degrading the performance of either system.
- C. Install wall-mounted equipment, with tops of cabinets not more than 78 inches above the finished floor.
- D. Manual Fire-Alarm Boxes:
1. Install manual fire-alarm box in the normal path of egress within 60 inches of the exit doorway.
 2. Mount manual fire-alarm box on a background of a contrasting color.
 3. The operable part of manual fire-alarm box shall be between 42 inches and 48 inches above floor level. All devices shall be mounted at the same height unless otherwise indicated.
- E. Smoke-Detector Spacing:
1. Comply with the "Smoke-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for smoke-detector spacing.
 2. Smooth ceiling spacing shall not exceed 30 feet.
 3. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas shall be determined according to Annex A in NFPA 72.
 4. HVAC: Locate detectors not closer than 36 inches from air-supply diffuser or return-air opening.
 5. Lighting Fixtures: Locate detectors not closer than 12 inches from any part of a lighting fixture and not directly above pendant mounted or indirect lighting.
- F. Install a cover on each smoke detector that is not placed in service during construction. Cover shall remain in place except during system testing. Remove cover prior to system turnover.
- G. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct. Tubes more than 36 inches long shall be supported at both ends.
1. Do not install smoke detector in duct smoke-detector housing during construction. Install detector only during system testing and prior to system turnover.

- H. Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location. Do not install smoke detectors in sprinklered elevator shafts.
- I. Audible Alarm-Indicating Devices: Install not less than 6 inches below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille. Install all devices at the same height unless otherwise indicated.
- J. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 6 inches below the ceiling. Install all devices at the same height unless otherwise indicated.
- K. Device Location-Indicating Lights: Locate in public space near the device they monitor.

3.4 PATHWAYS

- A. Pathways above recessed ceilings locations may be routed exposed.
 - 1. Exposed pathways located less than 96 inches above the floor shall be installed in EMT.
 - 2. Fire alarm wiring shall be in rigid galvanized conduit in all inmate areas.
- B. Exposed EMT shall be painted red enamel.

3.5 CONNECTIONS

- A. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 36 inches from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.
 - 1. Smoke dampers in air ducts of designated HVAC duct systems.
 - 2. Electronically locked doors and access gates.
 - 3. Alarm-initiating connection to elevator recall system and components.
 - 4. Alarm-initiating connection to activate emergency shutoffs for gas and fuel supplies.
 - 5. Supervisory connections at valve supervisory switches.
 - 6. Supervisory connections at elevator shunt-trip breaker.
 - 7. Data communication circuits for connection to building management system.
- B. Connect two dedicated active telephone lines to the DACT; coordinate with communications system installer.

3.6 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- B. Install framed instructions in a location visible from fire-alarm control unit.

3.7 GROUNDING

- A. Ground shielded cables at the control panel location only. Insulate shield at device location.

3.8 FIELD QUALITY CONTROL

- A. Field tests shall be witnessed by authorities having jurisdiction.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections.
- D. Perform the following tests and inspections:
 - 1. Visual Inspection: Conduct visual inspection prior to testing.
 - a. Inspection shall be based on completed record Drawings and system documentation that is required by the "Completion Documents, Preparation" table in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
 - b. Comply with the "Visual Inspection Frequencies" table in the "Inspection" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.
 - 2. System Testing: Comply with the "Test Methods" table in the "Testing" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
 - 3. Test audible appliances for the public operating mode according to manufacturer's written instructions. Perform the test using a portable sound-level meter complying with Type 2 requirements in ANSI S1.4.
 - 4. Test audible appliances for the private operating mode according to manufacturer's written instructions.
 - 5. Test visible appliances for the public operating mode according to manufacturer's written instructions.
 - 6. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" section of the "Fundamentals" chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
- E. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.
- F. Fire-alarm system will be considered defective if it does not pass tests and inspections.
- G. Prepare test and inspection reports.
- H. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.

- I. Annual Test and Inspection: One year after date of Substantial Completion, test fire-alarm system complying with visual and testing inspection requirements in NFPA 72. Use forms developed for initial tests and inspections.

3.9 MAINTENANCE SERVICE

- A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by skilled employees of manufacturer's designated service organization. Include preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
 - 1. Include visual inspections according to the "Visual Inspection Frequencies" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
 - 2. Perform tests in the "Test Methods" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
 - 3. Perform tests per the "Testing Frequencies" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

3.10 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain fire-alarm system.

END OF SECTION 283111

SECTION 311000 - SITE CLEARING

PART 1 - GENERAL

1.01 SUMMARY

- A. Drawings and general provisions of the Contract, including General Conditions, Supplemental General Conditions, and Division 01 Specifications, apply to this Section.
- B. This Section specifies requirements for the following:
 - 1. Protection of existing vegetation and items to remain.
 - 2. Clearing and grubbing.
 - 3. Selective clearing and thinning.
 - 4. Disposal of material from clearing, grubbing, thinning and demolition in approved off-site disposal areas.

1.02 SITE CONDITIONS

- A. Site conditions existing during the bidding period will be maintained by the Owner insofar as is practical.
- B. Actual site condition variations that differ from those of the bidding period and which affect site clearing operations shall be brought to the attention of the Owner prior to the commencement of any site work.

1.03 DEFINITIONS

- A. Dripline: The area beneath the tips of the outermost branches of a tree or shrub
- B. Plant-Protection Zone: Area surrounding individual trees, groups of trees, shrubs, or other vegetation to be protected during construction, and indicated on the Drawings.
- C. Root Pruning: The systematic pruning of roots of plants growing in the field, to stimulate branching of roots and the production of fibrous roots.

PART 2 – PRODUCTS

Refer to 312500 Erosion and Sediment Controls for additional product requirements.

- A. Liquid Fertilizer:
 - 1. ROOTS Concentrate by Novozymes Biologicals, Inc.
 - 2. Approved Equal as recommended by a certified Arborist.

PART 3 - EXECUTION

3.01 EXISTING VEGETATION PROTECTION

- A. Protect existing vegetation using tree protection and/or construction fencing as shown in the construction documents. Tree protection fencing shall be chain link or wood, not orange safety fence. Tree protection fencing shall be installed with hand-digging. This fencing shall be installed in advance of any additional disturbance on site.
- B. Limb up and/or prune trees to remain that will be impacted by construction activities.

1. Pruning of existing limbs larger than 2-inches and roots larger than 1-inch in diameter require supervision of a certified Arborist.
2. No roots larger than 1-inch diameter may be cut without supervision of a certified Arborist. All roots shall be cut with root pruning equipment; under no circumstances should backhoes or equipment that rip, tear or pull roots be used.
- C. Soil Injections: Tree root systems that are likely to be negatively impacted by construction activities, or which are located within 20-feet of proposed structures, shall require a slow-release liquid fertilizer injection throughout the entire root zone before and after the construction activities. Trees transplanted from the project require the same injections.
 1. Trees not identified in advance for soil injection but believed to have sustained root system damage as determined by an arborist, shall receive root injection after construction activities are completed.
- D. Do not stockpile or store materials, park vehicles, or perform any construction activities within the dripline of trees to remain. Avoid foot traffic or impoundment of water within tree protection zones.
 1. If work within drip line is unavoidable, install 12-inch layer of wood chips and tree root protection mats.
- E. Strip and stockpile topsoil for reuse on site. Contractor shall not remove topsoil from site without written permission from Owner unless topsoil is to be stored off-site and brought back to site for placement.

3.02 CLEARING AND GRUBBING

- A. Clearing shall include cutting, removal, and off-site disposal of trees, bushes, shrubs, stumps, fallen timber, brush, refuse, trash, fencing and other incidental materials not required for reuse on the site.
- B. The Contractor shall grub the area within the clearing limits to completely remove stumps and root systems, except for those to remain or those to be transplanted.
- C. Depressions, excavations, and voids resulting from the removal of stumps or roots shall be filled with suitable material and compacted as specified under Section 313000 – EARTHWORK.

3.03 SELECTIVE CLEARING AND THINNING

- A. Selective clearing and thinning shall be completed as directed by the construction documents.
 1. No clearing shall take place prior to installing tree protection and safety fence.
- B. The work shall include the removal of dead and diseased tree limbs and plants and pruning and removal of live vegetation that interferes with the growth of other trees and plants. Areas of dense growth shall be thinned to provide room for healthy growth.
- C. Refuse Disposal: All logs, stumps, brush, wood, and refuse shall be disposed of off the property in an approved landfill. Consideration will be given to Contractor mulching logs, brush, and wood for use on campus where appropriate. On-site burning is prohibited.
- D. Plant Protection: Trees, within the project limits are to be protected with tree protection fencing at or beyond the drip line to prevent damage by equipment and external construction activities.

3.04 DEMOLITION

- A. Refer to 024113 Selective Site Demolition for removal of site structures and utilities.

3.05 DISPOSAL OF DEMOLISHED MATERIALS

- A. Remove from site all materials resulting from site clearing and demolition operations.
- B. No material may be burned or buried onsite.

END OF SECTION 311000

SECTION 312000 - EARTHWORK

PART 1 - GENERAL

1.1 SUMMARY

- A. Drawings and general provisions of the Contract, including General Conditions, Supplemental General Conditions, and Division 01 Specifications, apply to this Section.
- B. The work of this section includes but is not necessarily limited to:
 - 1. Site preparation
 - 2. Dewatering
 - 3. Excavation
 - 4. Filling and backfilling, refer also to 312333 Trenching and Backfilling for utilities
 - 5. Rough and fine grading
 - 6. Compaction
- C. Obtain all required permits, licenses, and approvals of authorities having jurisdiction prior to commencing the work of this Section, and pay costs incurred therefrom.
- D. Notify all affected utility companies and Miss Utility of Virginia a minimum of five (5) working days before starting work.

1.2 QUALITY ASSURANCE

- A. The Owner will retain and pay for the services of an independent testing and inspection firm and/or a Geotechnical Consultant, hereafter referred to as the "OGC," to perform on-site observation and testing during the various phases of the construction operations. The scope of services will be determined by the Owner and the OGC and will be provided to the Contractor. The Owner reserves the right to modify or waive the services of the OGC. Their services may include, but not necessarily be limited to, the following:
 - 1. Observation during excavation and dewatering of building areas and controlled fill areas.
 - 2. Laboratory testing and analysis of fill materials as specified herein and proposed by the Contractor for incorporation into the Work.
 - 3. Observation of construction and performance of water content, gradation and compaction tests at a frequency and locations that the OGC may require. The results of these tests will be submitted to the Owner, the Architect, and Contractor on a timely basis so that action can be taken to remedy indicated deficiencies. During construction, the OGC will advise the Owner, in writing, if at any time in their opinion the Work hereunder is of unacceptable quality. Failure of the OGC to give notice, shall not excuse the Contractor from latent defects discovered in his work.
- B. The Contractor shall make provisions for allowing observations and testing of Contractor's work by the OGC.
- C. The presence of the OGC does not include supervision or direction of the actual work of the Contractor, and their employees or agents. Neither the presence of the OGC, nor any

observations and testing performed by them, nor failure to give notice of defects shall excuse the Contractor from defects discovered in their work.

- D. Costs related to retesting due to unacceptable qualities of work and failures discovered by testing shall be paid for by the Contractor at no additional expense to Owner, and the costs thereof will be deducted by the Owner from the Contract Sum.

1.3 SUBMITTALS

- A. Rock Measurement: volume of rock actually removed, measured in original position, but not to exceed the following:
 - 1. 24 inches outside of concrete forms other than at footings
 - 2. 12 inches outside of concrete forms at footings
 - 3. 6 inches outside of minimum required dimensions of concrete cast against grade
 - 4. Outside dimensions of concrete walls indicated to be cast against rock without forms or exterior waterproofing treatments.

Unit prices for rock excavation shall include replacement with approved materials.

- B. If requested by the Owner's testing agent, submit a sample of each type of off-site fill material that is to be used at the site. Submit samples a minimum of one week prior to use of proposed material at the site. Use of these proposed materials by the Contractor prior to testing and/or approval by the OGC shall be at the Contractor's risk.
- C. The OGC will be responsible for the approval or rejection of the suitability of all earthwork materials.
- D. Submit the name of each material supplier and specific type and source of each material to the OGC. Any change in source throughout the project requires approval of the Owner/owner's agent.

1.4 SUBSURFACE SOIL DATA

- A. Geotechnical report, "Geotechnical Report: Band and Choral Room Colonial Heights High School" by GeoTex Engineering, PLC dated April 4, 2022 is included in the Appendix of the Project Manual.

1.5 DEFINITIONS

- A. This site is considered classified.
Classified excavation: removal and disposal of all materials not defined as Rock or Unsuitable.
- B. Backfill: Soil material or controlled low-strength material used to fill an excavation. Also referred to as Fill.
- C. Base Course: Aggregate layer placed between the subbase course and hot-mix asphalt paving.
- D. Bedding Course: Aggregate layer placed over the excavated subgrade in a trench before laying pipe.
- E. Blasting: blasting is not allowed.

- F. Borrow Soil: Satisfactory soil imported from off-site for use as fill or backfill.
- G. Debris: All materials located within the designated work area not covered in the other definitions and shall include but not be limited to items like vehicles, equipment, appliances, building materials or remains thereof, tires, any solid or liquid chemicals, or products stored or found in containers or spilled on the ground.
- H. Excavation: Removal of material encountered to subgrade elevations and the reuse or disposal of materials removed.
 - 1. Unauthorized Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions without direction by the OGC. Unauthorized excavation, as well as remedial work directed by OGC, shall be without additional compensation.
 - 2. Authorized Additional Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions as directed by the OGC. Authorized additional excavation and replacement material will be paid for according to Contract provisions for unit prices and changes in the Work.
 - 3. Bulk Excavation: Excavation more than 10 feet in width and more than 30 feet in length.
- I. Porous Fill: Layer of washed granular material supporting slabs-on-grade used to minimize capillary flow of pore water.
- J. 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 the following in size and performance ratings without systematic drilling, ram hammering, or ripping (blasting is not permitted):
 - 1. Equipment for Footing, Trench, and Pit Excavation: Late-model, track-mounted hydraulic excavator; equipped with a 42-inch- maximum-width, short-tip-radius rock bucket; rated at not less than 138-hp flywheel power with bucket-curling force of not less than 28,090 lbf and stick-crowd force of not less than 19,000 lbf; measured according to SAE J-1179. (i.e. CAT 320 hydraulic excavator or comparable equipment.)
 - 2. Equipment for Bulk Excavation: Late-model, track-mounted loader; rated at not less than 210-hp flywheel power and developing a minimum of 48,510-lbf breakout force with a general-purpose bare bucket; measured according to SAE J-732. (i.e. Caterpillar's "Model No. 973C or comparable equipment.)
- K. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.
- L. Subbase Course: Aggregate layer placed between the subgrade and base course for hot-mix asphalt pavement, or aggregate layer placed between the subgrade and a cement concrete pavement or a cement concrete or hot-mix asphalt walk.
- M. Subgrade: The uppermost surface of an excavation; the top surface of a fill or backfill; and/or the undisturbed earth or the compacted soil layer immediately below granular subbase, drainage fill, or topsoil materials.
- N. Unsuitable Soil: Soil that is unsatisfactory or not suitable for obtaining the compaction requirements specified in this Section. Soils are not deemed unsuitable due to moisture content. Unsuitable material shall be determined/confirmed by Owners Geotechnical Consultant.

- O. Utilities: On-site underground pipes, conduits, ducts, and cables as well as underground services within buildings.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. General: Provide regionally extracted fabricated fill, soil, gravel, and sand. Provide approved borrow soil materials from off-site when sufficient approved soil materials are not available from excavations. Contractor shall locate appropriate off-site borrow areas and ensure appropriate permits are in place for any off-site operations.
- B. Structural Fill: material free from ice and snow, boulders, roots, sod, rubbish, debris and other deleterious or organic material and shall have a maximum particle size no greater than three (3) inches. Approved on-site, non-organic portions of material excavated may be used as structural fill. If off-site borrow soils are required, they must classify as SC, SM, SP, SW, GC, SM, GP or SW per ASTM D2487 and have a minimum CBR value no less than 6 percent.
- C. Common Fill/Ordinary Borrow: friable soil containing no stone greater than two-thirds (2/3) the loose lift thickness with a maximum stone size of twelve (12) inches in diameter. The material shall be essentially free of trash, ice, snow, tree stumps, roots, and organic materials. The soil shall contain no more than 15 percent passing the #200 sieve.
- D. Trench Backfill: structural fill. Where trench is located under roads, sidewalks, or parking, trench backfill shall be VDOT #21A stone.
- E. Porous Fill: washed VDOT #57 stone.
- F. Sand: shall consist of clean, inert, hard, durable grains of quartz or other hard, durable rock, free from loam or clay, surface coatings and deleterious materials.
 - 1. The allowable amount of material passing a No. 200 sieve as determined by AASHTO-T11 or ASTM D422 shall not exceed 10 percent by weight. The maximum particle size shall be 1/4-inch (i.e., 100 percent passing the No. 4 sieve).
 - 2. In addition to the above criteria, when sand is used for utility bedding, it shall conform to the following gradation:

<u>Sieve (ASTM D422)</u>	<u>Percent Passing by Weight</u>
No. 4	100
No. 8	80 – 95
No. 16	55 – 85
No. 50	0 – 35
No. 200	0 – 5

- G. Stone Fill: VDOT #2 or #3 stone.
- H. Filter Fabric / Geotextiles:
 - 1. Geotextile fabric shall be used to prevent soil intrusion into drains and/or assist in stabilizing soil subgrades to be laid on approved soil subgrades prior to placement of fill materials.
 - a. Contractor shall use permeable filter fabric in drainage recharge systems, underdrain systems between crushed stone and granular soils, leaching areas, or where indicated on

the plans. Minimum flow rate of 145 gal/min/sf, inert to biological degradation, and minimum CBR puncture strength of 250 lbs.

I. Controlled Low Strength Material or Controlled Density Fill (Flowable Fill):

1. Controlled low strength material or controlled density fill shall be a cement concrete backfill material that flows like a liquid, supports like a solid when cured, and levels without tamping or vibrating to reach 100 percent compaction. The material shall be used primarily as a backfill in lieu of compacted fill. The material shall be proportioned to yield a 28—day minimum compressive strength of 200 pounds per square inch. The material shall be produced and installed in accordance with ACI 229R, and ACI 116R, with a mix formulation to be approved by Owner's Geotechnical Consultant prior to placement of the material in the project.

J. Topsoil/Loam

1. Topsoil (stripped from site) or Loam (supplied from off-site) shall be a sandy loam or loam soil classification as defined by the USDA Soil Conservation Service, Soil Classification System consisting of a fertile, friable, natural topsoil/loam typical of locality, without admixture of subsoil, refuse or other foreign materials, shall be obtained from a well-drained arable site, and shall meet ASTM D5268. Material shall be such a mixture of sand, silt and clay particles as to exhibit sandy and clayey properties in about equal proportions. Material shall be free of stumps, roots, heavy or stiff clay, stones larger than 3/4-inch in diameter, lumps, coarse sand, noxious weeds, sticks, brush or other litter, and shall have the following mechanical analysis:

Textural Class	Percent of Total Weight	Average Percent
Sand 0.05 - 2.0 mm dia. range	45 to 75	60
Silt 0.002 - 0.05mm dia. range	15 to 35	25
Clay less than 0.002 mm dia. range	5 to 25	15

- a. 95 percent of Topsoil shall pass a 2.0 mm sieve.
- b. Topsoil/Loam shall have a pH value in the range of 6.0 to 7.0. If Topsoil/Loam material does not fall within the required pH range, limestone or aluminum sulfate shall be added to bring the pH within the specified limit.
2. Prior to stripping, the topsoil shall demonstrate, by the occurrence upon it of healthy crops, grass or other vegetative growth, that it is reasonably well drained and that it does not contain toxic amounts of either acid or alkaline elements.
3. Loam and topsoil shall contain not less than 4 percent nor more than 20 percent organic matter as determined by the loss on ignition of oven-dried samples. Test sample shall be oven-dried to a constant weight at a temperature of 230°F. ±9°.
4. In other portions of these specifications, the words 'loam' and 'topsoil' are used interchangeably.

2.2 USE OF MATERIALS

- A. Use of materials shall be as described below and as shown on the plans. Further details can be found in the project plans. Combinations or layering of materials may be necessary in certain instances such as for detention embankments, subsurface disposal areas, and riprap walls as examples.
1. Common/Ordinary Fill: Use common/ordinary fill for general grading as backfill, and as embankment fill in areas outside the building and pavement limits. Stones larger than twelve inches (12") shall be removed prior to compaction.
 2. Gravel: Use for pipe bedding backfill and backfill below pavement and slab as base course layer. Use for drainage course layer. Use for material placed "in the wet". Use for backfilling behind retaining walls and retaining structures. Use for pipe and utility bedding.
 3. Sand: Use for conduit bedding and initial backfill, and gas line bedding and backfill. Use for bedding and backfill of direct burial cables and/or flexible piping. Use for bedding and filling joints for concrete unit pavers.
 4. Crushed Stone: Use crushed stone as a filter material around perforated pipe and as bedding for piping under wet subgrade conditions.
 5. Dense-Graded Crushed Stone: Use dense-graded crushed stone for subbase and base material.
 6. Structural Fill: Use structural fill below subgrade elevation in building areas such as beneath floor slabs, foundations, and in other soil bearing situations. Structural fill shall also be used for back-fill against building foundations and frost walls. Use structural fills below pavement gravel base course and below pipes within fill areas.
 7. Stone Fill: Use stone fill as additional storage medium for underground stormwater exfiltration trenches or pits.
 8. Filter Fabric/Geotextiles: To be used as filter barriers between drainage recharge systems, underdrain systems, wastewater absorption systems, and between natural earth material and backfill or other materials to assist in stabilizing soil subgrades.
 9. Riprap: Use riprap for slope stabilization and for erosion control in channel bottoms, overflow areas, level spreaders, and where indicated.
 10. Channel Paving and Grouted Channel Paving: Use stone for channel paving and grouted channel paving in and around watercourses to prevent erosion, scour, and instability of the channel bottom and side slopes.
 11. Filter Stone Layer: Use filter stone layer under riprap, stone for pipe ends, slope paving, channel paving and grouted channel paving, or where indicated.
 12. Controlled Low Strength Material or Controlled Density Fill: May be used for trench backfill, anti-flotation bases, and/or lightweight backfill.
 13. Topsoil/Loam: Use as fill in designated landscape and lawn areas; if off-site material is required, Loam shall be furnished and installed. Topsoil maybe used as fill in landscape and lawn areas if an excess of topsoil exists on-site.

PART 3 - EXECUTION

3.1 SITE PREPARATION

- A. Refer to 311000 Site Clearing for protection and removal of existing vegetation. Refer to 02 41 13 Selective Site Demolition for removal of other site improvements and utilities.
- B. Strip all topsoil, subsoil, and other unsuitable materials to its full depth within the Contract limits and as recommended in the Geotechnical Report. Remove all topsoil, subsoil, vegetative matter, and non-soil materials and, after screening out the roots, rocks greater than 3/4 inch in size, and deleterious debris, separately stockpile the topsoil and subsoil materials. Only excess topsoil may be removed from site without Owner's permission.
- C. Under pavement areas, unsuitable materials shall be removed and disposed of by the Contractor in a legal location off-site and replaced with structural fill. If approved by OGC, unsuitable materials may be allowed to remain on site in non-structural areas. If on-site, material shall be processed to remove all roots, stones larger than 3/4 inch in diameter, and other deleterious materials. Unsuitable material stockpile shall remain separate from other stockpiles.
- D. Where underground project work is in close proximity to existing buried utilities or other existing underground improvements, the contractor shall cautiously execute exploratory excavation(s) to verify exact horizontal and vertical positions of existing systems. Provide exploratory excavation findings to the Architect, in order to avoid conflict and maintain required separations and clearances, the results may require design adjustments.

3.2 DEWATERING

- A. Provide, operate, and maintain site and subsurface drainage and dewatering in an acceptable manner as required to complete the work throughout the course of the project.
- B. Remove, by pumping or other means, water accumulated in excavations and within two (2) feet below subgrade until earthwork, utilities, concrete, and other work operations are complete. Dewatering shall be considered incidental to the defined work items and costs for performing same shall be included in the bid price(s) and no separate payment shall be made to the Contractor for dewatering operations.
- C. Provide, maintain, and operate wells, pumps, and related equipment including stand-by equipment of sufficient capacity to maintain excavations and trenches free of water 24 hours per day to enable all work to be conducted in-the-dry and to protect bearing surfaces from disturbance.
- D. Water from excavations shall be disposed of in such manner as will not cause injury to public health, public and private property, existing work, work to be completed or in progress, roads, walks, or interfere with use of the same. Concrete or fill shall not be placed in excavations containing free water.
 - a. Water suspected of having chemical or biological contamination or to contain anything other than pure rain or groundwater shall be evaluated for proper disposal options in coordination with the environmental inspector. Potential disposal options may include discharging to the sanitary sewer, hauling to off-site permitted disposal facility, or on-site treatment and discharge.
- E. Construction may require excavation below water level in soil. The Contractor shall complete this work in-the-dry to maintain the undisturbed condition of the bearing soil.

- F. Maintain groundwater at least two (2) feet below lowest exposed subgrade level. If the dewatering methods have not been adequate and the bearing soils are disturbed, remove disturbed soil, and replace with compacted Structural Fill or lean concrete at no additional cost to the Owner.
- G. Sumps shall be surrounded by suitable filter media to minimize the fines removed during pumping.
- H. Pumped groundwater and surface water runoff shall be initially pumped to a settling basin or sediment bag to remove suspended solids prior to discharge. The Contractor shall furnish all treatment systems that are necessary for pretreatment of groundwater prior to discharge in accordance with all applicable permits and regulations.
- I. Discharge of pumped water, either surface water runoff or groundwater, shall follow discharge criteria contained in permits issued by governing agencies, and all legal requirements and regulations. All permits shall be obtained by the Contractor.

3.3 EXCAVATIONS

A. Site General Requirements

- 1. Control the grading so that ground is pitched to prevent water from running to excavated areas, damaging other structures, or adjacent properties.
- 2. Where soil has been softened or eroded by flooding, equipment, traffic, or placement during unfavorable weather, or such other conditions as confirmed by OGC, it shall be removed and replaced by the Contractor with suitable material and at no cost to the Owner.
- 3. Exercise care to preserve the material below and beyond the lines of excavation. Where excavation is carried out below indicated grade or beyond the lines of excavation, Contractor shall backfill and compact the over excavation with structural fill to the indicated grade, at no additional cost to the Owner and at the direction of the OGC.
- 4. Provide sheeting, shoring, and bracing to complete and protect all excavated areas, as required for safety and compliance with OSHA. Costs for sheeting, shoring, and bracing shall be included as a part of the Contract Price for completing the work and Owner shall make no separate payment for this work.
- 5. Excavated materials unsuitable for reuse, surplus excavated rock, and surplus excavated soil not used to fulfill requirements of the Contract, shall become the property of the Contractor and shall be removed from the site in accordance with the regulations and requirements of all municipalities or agencies having jurisdiction over the disposal sites and the route between the project and the disposal sites.
- 6. Limits of excavation are such that all unsuitable material shall be removed to firm natural ground in the manner specified below. In building areas, unsuitable materials shall be removed to ten feet (10') beyond the building lines or within the area defined by a one horizontal to one vertical (1h:1v) line sloping down from outside bottom edge of exterior footings to firm natural ground, whichever is greater. Limits of unsuitable material excavation also apply to areas below column and wall footings. All abandoned utility lines within building areas must be removed and the excavations shall be properly backfilled.

7. In addition to unsuitable material identified in the Geotechnical Report, unsuitable materials are classified as organics such as peat, trash, fill, stumps, debris, material determined to be hazardous, and topsoil and subsoil when determined by the OGC to be unacceptable for incorporation into the work.
8. Topsoil need not be excavated from pavement areas if located more than three feet (3') below finish pavement grades. Trees may be cut flush with ground and stumps may be left in place if the existing ground surface is located more than six feet (6') below finish grades. Abandoned pipes, that are buried more than four feet (4') from finish grade to the top of the pipe and that do not interfere with utilities to remain or to be installed, shall be capped and/or grouted at both ends and left in place. Abandoned pipes less than four feet (4') from finish grade shall be removed and the trench shall be appropriately backfilled with structural fill. All abandoned pipes shall be removed from building footprints.
9. All suitable material, as determined by the OGC, may be reused on the site provided it meets the gradation requirements for the given materials in the information of fill sections, embankments, subgrades, backfills, etc.
10. Do not over excavate below proposed design grades for obtaining borrow for use off-site.
11. Termite/Insect Treatment: A licensed professional shall treat all new excavations for termite and insect infestation. Specify under slabs, along foundation walls, around all openings and protrusions in slabs on grade.

B. Proof Rolling

1. Prior to placing compacted fills, the Contractor shall proof roll the natural grades to remain. Where materials of low density are indicated by rutting or weaving under the compactor, the Contractor may be required to make up to three (3) additional complete coverages of the area with the compactor as determined by the OGC. The cost of all proof rolling shall be included in the Contract Price. If materials of low density are encountered that cannot be compacted to the extent necessary to support the proposed embankment fills as determined by the OGC, the Contractor shall remove those materials and replace them with compacted fill.

3.4 TRENCH EXCAVATION

- A. Refer to 312333 Trenching and Backfilling for trench excavation requirements.
- B. Excavate as necessary for all drainage pipes, utilities, and related structures and appurtenances, and for any other trenching necessary to complete the work.
- C. Definitions:
 1. Trench shall be defined as an excavation of any length where the width is less than twice the depth and where the shortest distance between payment lines does not exceed ten feet (10'). All other excavations shall be defined as open excavations.
 2. The words "invert" or "invert elevation" as used herein shall be defined as the elevation at the inside bottom surface of the pipe or channel.
 3. The words "bottom of the pipe" as used herein shall be defined as the base of the pipe at its outer surface.
- D. In general, machine excavation of trenches will be permitted except for preparation of pipe beds which will be hand work. Excavate by hand or machine methods to at least six inches (6")

below the bottom of pipe or as shown on the Drawings. Excavation to final grade shall be made in such a manner as to maintain the undisturbed bearing character of the soils exposed at the excavation level.

- E. Utilities or piping shall not be laid directly on boulders, cobbles, or other hard material. This material shall be removed to a minimum of six inches (6") below the bottom of pipe at all points and backfilled or compacted as specified.
- F. Remove unsuitable material encountered at subgrade elevations, backfill with material specified herein and as otherwise indicated on the Drawings, specified, or directed. Compact as specified with approved compactors.
- G. In general, the width of trenches shall be kept to a minimum per detail provided.

3.5 ROCK EXCAVATION

A. Clearance Limits

- 1. Foundations and Slabs: Within the limits of the concrete lines as defined by the working plans or by duly authorized modifications thereto, plus twelve inches (12") outside the vertical concrete lines and twelve inches (12") below base.
- 2. Utility Trenches: All parts of pipe, valves, and fittings to a depth of six inches (6") below the bottom of the bell and for a width equal to the outside diameter of the pipe, plus fifteen inches (15") beyond the outside diameter on each side.
- 3. Paved Areas: To the underside of the respective subbase for such areas.
- 4. Site Structures: Twelve inches (12") outside of structure all around.
- 5. Lawn areas and shrub planting areas: To a depth of eighteen inches (18") below finished grade.
- 6. Planting areas for trees over two inches (2") in caliber size: To depth of thirty-six inches (36") below finished grade and for a radius of 3 feet (3') around each tree, except volumes in radius areas shall not overlap.
- 7. Any foreseen rock or boulder encountered, as defined above, which must be removed for construction of the work defined on the plans or in modification thereto.

B. Reuse of Excavated Rock

- 1. Riprap
 - a. Excavated rock may be used as riprap, for construction of stone masonry walls, and for sloped riprap for retaining walls, provided that the rock is judged to be adequate quality by the OGC and the rock is sufficiently broken to meet gradation requirements established for the intended use
- 2. Fills
 - a. Reuse of excavated rock for fill materials shall require prior approval of the OGC and shall require compliance with gradation requirements for the specific type of fill for which it is being used.

3.6 PREPARATION OF EXCAVATION BOTTOMS

A. Building and Pavement Areas

1. Prior to placing crushed or choked stone, the area is rolled with at least four (4) passes of a heavy vibratory roller, RayGo 600 or equal.
2. Proof-roll subgrade with a vibratory roller or by minimum of two (2) passes of a fully loaded ten-wheeled dump truck. Soft or hard areas and other objectionable material (stumps, wood, organics) shall be excavated and backfilled with compacted structural fill.

B. Subgrades under Proposed Landscape Areas.

1. In lawn areas, scarify subsoil a minimum depth of six inches (6"). Subsoil shall also be cleared of debris and stones larger than four inches (4") prior to topsoil spreading.
2. In planting areas, scarify subsoil a minimum depth of six inches (6") below the required root ball excavation prior to placement of plant backfill mixture.

C. Trenches

1. Refer to 312333 Trenching and Backfilling specification.
2. Compaction equipment used in open areas where space permits shall consist of vibratory rollers weighing at least 15,000 pounds, fully loaded ten-wheel dump trucks, pneumatic compactors, or other similar equipment.
3. Compaction equipment for fill against foundation walls and in other confined areas shall be accomplished by means of drum-type, power-driven, hand-guided vibratory compactors operating at 2,000 cycles per minute, or by hand-guided vibratory plate tampers.

D. Excavation for Structures: Conform to elevations and dimensions shown within a tolerance of plus or minus 0.10 foot and extending 5'-0" from footings and foundations.

1. In excavation for footings and foundations, take care not to disturb bottom of excavation. Excavate by hand to final grade just before concrete reinforcement is placed. Trim bottoms to required lines and grades to leave solid base to receive other work. Place concrete in footings the same day of excavation.
2. Any foundation excavation encountering disturbed, soft, or loose soils at the proposed bearing elevation shall be extended to a suitable soil stratum as recommended by the OGC.
3. Coordinate footing depth with all utility lines.
4. Any authorized footing over-excavation must be filled with flowable fill or lean concrete. Gravel may not be used as fill under footings.

3.7 BACKFILLING AND PLACEMENT OF FILL MATERIALS

A. Site

1. Dewater subgrade areas prior to filling.
2. Compaction by puddling or jetting is prohibited.
3. Control groundwater and surface runoff to minimize disturbance of exposed natural ground surface, previously placed and compacted fill and material being placed.

4. Soil fill moisture shall be maintained at an acceptable working range to allow for proper compaction.
 5. Do not place fill on frozen ground.
 6. Do not place frozen fill.
 7. Place fill in uniform horizontal layers and compact immediately after placement. Where the horizontal layer meets a rising slope, the layer shall be keyed into the slope by cutting a bench during spreading of preceding lift.
 8. To the extent that is practical, each layer of fill shall be compacted to the specific density the same day it is placed.
 9. Slope fill surfaces at the end of each day to provide for free surface drainage.
 10. Protect structures and pipes from damage during backfilling operations. Repair damage at no cost to Owner.
 11. Placement of fill shall not begin prior to observation and approval of subgrade conditions by OGC.
 12. Protect foundations, footings, and waterproofing during backfilling. Repair damage at no cost to Owner.
 13. Prior to backfilling between foundation wall and sheeting, remove unsuitable material, including rubbish, organic materials, or other debris. Do not commence filling operations until conditions have been observed by OGC.
 14. Backfill shall not be placed against walls until they are braced or have cured sufficiently to develop strength necessary to withstand, without damage, pressure from backfilling and compacting operations.
 15. Provide shoring, sheeting, and bracing of excavations as required to assure complete safety against collapse of the earth at the site of excavations. Alternatively, lay back excavations to suitable slope.
 16. Upon completion of the work, the final ground surface shall be left in a firm, unyielding, true, uniform condition free from ruts. Repair disturbed areas caused by equipment traffic at no cost to Owner.
- B. Equipment
1. Compaction equipment used in open areas where space permits shall consist of vibratory rollers weighting at least 15,000 lbs., fully loaded ten-wheel dump trucks, pneumatic compactors, or other similar equipment.
 2. Compaction equipment for fill against foundation walls and in other confined areas shall be accomplished by means of drum-type, power-driven, hand-guided vibratory compactors operating at 2,000 cycles per minute, or by hand-guided vibratory plate tampers.
- C. Placing Fill
1. Fill sections and embankments shall be constructed of earth, rock, or a mixture of earth and rock deposited in successive lifts. Except as hereinafter permitted, the loose thickness of each lift shall not be more than twelve inches before compaction.
 2. No rock more than three inches (3") in its largest dimension shall be incorporated in the top two-foot (2') layer of embankment immediately below the subgrade.

3. During fill and embankment construction operations, earth moving equipment shall be routed as evenly as possible over the entire width of the work.
 4. At the close of each day's work the working surface shall be crowned, shaped, and rolled with smooth steel or pneumatic tired rollers to ensure proper drainage.
 5. Prior to placing compacted structural fill below, the slab, the surface of natural ground, shall be proof rolled with at least four (4) passes of a heavy vibratory drum roller, such as a RayGo 600, or equal. Hard and soft spots shall be excavated and replaced with structural fill or other material acceptable to the OGC.
 6. Where excavations for slab-on-grade extend to weathered fractured or blasted bedrock, the OGC shall assess the rock surface for the presence of voids and may require placement of a 2 inch to 18-inch layer of choke stone or crushed stone prior to placement of structural fill.
- D. Fills under Parking Areas
1. Paved area subgrades shall be excavated to a minimum of 12 inches (12") beneath required subgrade elevation or existing grade, whichever is lower.
 2. Proof-roll subgrade with a vibratory roller or by minimum of two (2) passes of a fully loaded ten-wheeled dump truck. Soft or hard areas and other objectionable material (stumps, wood, organics) shall be excavated and backfilled with compacted common fill.
- E. Subgrades under Proposed Landscape Areas
1. Fills under tree and shrub planting areas shall be backfilled with topsoil/loam materials.
- F. Buildings
1. Crushed Stone Placement and Compaction:
 - a. Maximum lift thickness prior to compaction shall be 8".
 - i. Structural Fill: Compacted structural fill shall be placed in maximum 8" lifts immediately below the slabs.
 - ii. Slabs on grade shall have a 4" drainage layer consisting of VDOT #57 stone.

3.8 BACKFILLING AGAINST STRUCTURES

- A. Backfilling against masonry or concrete shall only be done when approved. The Contractor shall not place backfill against or on structures until they have attained sufficient strength to support the loads (including construction loads) to which they will be subjected, without distortion, cracking, or other damage. As soon as practicable after the structures are structurally adequate and other necessary work has been satisfactorily completed, any leakage tests or other testing of the structures shall be made by the Contractor, as required by the OGC, at the Contractor's expense.
1. After the satisfactory completion of leakage tests and the satisfactory completion of any other required work in connection with the structures, the backfilling around the structures shall proceed using suitable and approved excavation material. Backfill material shall be used for backfilling within 2 feet (2') of the structure. All foundations that are retaining walls must have VDOT #57 gravel backfill up to 4' from the finished surface elevation. The final 4' shall be backfilled with soils such as CL or SC placed in 6" lifts. Just prior to placing backfill, the areas shall be cleaned of all excess construction material and debris and the bottom of excavations shall be in a thoroughly compacted condition.

- B. Symmetrical backfill loading shall be maintained. Special care shall be taken to prevent any wedging action or eccentric loading upon or against the structures.
 - 1. During backfilling operations, care shall be exercised that the equipment used will not overload the structures in passing over and compacting these fills. Except as otherwise specified or directed, backfill shall be placed in layers not more than 8 inches (8") in loose depth and each layer of backfill shall be compacted thoroughly and evenly using approved types of mechanical equipment. Each pass of the equipment shall cover the entire area of each layer of backfill.
- C. In compacting and other operations, the Contractor shall conduct their operations in a manner to prevent damage to structures due to passage of heavy equipment over and adjacent to structures. Repair damage made by the Contractor, at no additional cost to the Owner.
- D. After backfilling the Contractor shall maintain the surfaces of backfill areas in good condition to present a smooth surface always level with adjacent surfaces. The Contractor shall repair any subsequent settling over backfilled areas immediately, in a manner satisfactory to the OGC, and such maintenance shall be provided by the Contractor for the life of this Contract, at no additional cost to the Owner.
- E. The finished subgrade of the filled excavations upon which pavements are to be constructed shall not be disturbed by traffic of other operations and shall be maintained in a satisfactory condition until the finished courses are placed. The storage or stockpiling of materials on finished subgrade will not be permitted.
- F. Uniformly smooth grade all areas to be graded, as indicated including excavated sections and all areas disturbed because of the Contractor's operations. The finished surfaces shall be reasonably smooth, compacted, and free from surface irregularities.

3.9 COMPACTION

A. Compaction Requirements

- 1. The degree of compaction is expressed as a percentage of the maximum dry density at optimum moisture content as determined by ASTM D698, Method A. The compaction requirements are as follows, or as recommended by the OGC based on field conditions:

Area	Minimum Degree of Compaction
Below footings	95%
Below slabs	95%
Detention basin berms	98%
Pavement base course	95%
Pavement subbase	95%
12" fill below pavement subbase	100%
Additional fill below pavement	95%
Trench backfill	95%
Building and structure backfill	98%
Lawn areas	90%

2. Compaction percentages are based on the laboratory derived Maximum Density Values.

B. Moisture Control

1. Fill that is too wet for proper compaction shall be harrowed or otherwise dried to a proper moisture content to allow compaction to the required density. If fill cannot be dried within 24 hours of placement, it shall be removed and replaced with drier fill. On-site soils shall not be deemed unsuitable based on moisture content; earthwork should be performed during the warmer, drier times of the year to avoid delays due to scarifying and drying.
2. Fill that is too dry for proper compaction shall receive water uniformly applied over the surface of the loose layer. Sufficient water shall be added to allow compaction to the required density.
3. In no case shall fill be placed over material that is frozen. No fill material shall be placed, spread, or rolled during unfavorable weather conditions. When work is interrupted by heavy rains, fill operations shall not be resumed until the moisture content and the density of the previously placed fill are as specified.

C. Lift Thickness of Material

1. Structural Fill and Sand Borrow. Place in layers not to exceed 8 inches (8") in thickness when utilizing heavy compaction equipment, 6 inches (6") when utilizing light hand-operated compaction equipment, and 4 inches (4") along foundation walls or within a 45-degree angle from the footing.
2. Common Fill. Place in layers not to exceed 8 inches (8") in thickness.
3. Crushed Stone, Gravel, Dense, Graded Crushed Stone for Subbase. Place in layers not to exceed 8 inches (8") in thickness when utilizing heavy compaction equipment, and 6 inches (6") when utilizing light hand-operated compacted equipment. Compact with a minimum of four (4) coverages of acceptable compaction equipment.
4. All moisture ranges below the building area must be approved by OGC.

D. Placing Fill

1. Fill sections and embankments shall be constructed of earth, rock, or a mixture of earth and rock deposited in successive lifts. Except as hereinafter permitted, the loose thickness of each lift shall not be more than eight inches (8") before compaction.
2. Rock fill may be used in deep fill areas.
3. No rock more than three inches (3") in its largest dimension shall be incorporated in the top two (2) foot layer of embankment immediately below the subgrade.
4. During fill and embankment construction operations, earth moving equipment shall be routed as evenly as possible over the entire width of the work.
5. At the close of each day's work the working surface shall be crowned, shaped, and rolled with smooth steel or pneumatic tired rollers to ensure proper drainage.

E. Protection of Fill

1. Protection of compacted fill shall be the responsibility of the Contractor. Newly graded areas shall be protected from the actions of the elements and traffic. Any settlement or washing that occurs prior to acceptance of the work shall be repaired and grades shall be established to the required elevations and slopes. Damage to any compacted lift (including those lifts previously tested and approved by the OGC) occurring at any time during construction, which is caused by equipment, moisture entering the embankment, or from any other cause, shall be fully repaired by the Contractor prior to placement of overlying materials, at no additional cost to Owner and to the complete satisfaction of the OGC.
2. In the event of and prior to the commencement of heavy rains, the Contractor shall suspend fill operations immediately and shall take all necessary steps to keep the site as well drained as possible. Fill operations shall not be resumed until the moisture content of the fill is such as to permit compliance with the Specifications.
3. All corrective work or operations necessary to maintain proper moisture control of the fill material shall be at the expense of the Contractor.

F. Grading Tolerances for Subgrades: confirm subgrades tolerances are met prior to installing pavements and finished grades.

1. Grading shall be completed to meet or exceed the following tolerances of uniformity*:

<u>Location</u>	<u>Tolerance</u>
Top of Subgrade Beneath Paving	1/2 inch
Top of Subgrade Beneath Landscape Areas	1 inches
Top of Gravel and Gravel Bases	1/4 inch

*Uniformity is defined as no variations in the surface materials at the grades and slopes indicated on the Drawings that exceed the listed tolerance over a length of ten feet (10') horizontally in any direction.

2. The bottom of earth and rock excavations shall be formed to provide a smooth, uniform slope and grade. The bottom of the excavated grade shall be free of pockets, depressions or ridges that would collect or concentrate water, silts, or other such objectionable material prior to the placement of backfill or other finish materials.

G. Finish

1. Upon completion of the work, ground surface shall be left in a firm, unyielding, true, uniform condition, free of ruts.

END OF SECTION 312000

SECTION 312213 - ROUGH GRADING

PART 1 - GENERAL

1.01 WORK INCLUDED

- A. Remove topsoil and stockpile for later reuse.
- B. Excavate subsoil and remove excess from site.
- C. Grade and rough contour site.

1.02 RELATED WORK

- A. Section 312316 - Excavation
- B. Section 312333 – Trenching and Backfilling

1.03 PROJECT RECORD DOCUMENTS

- A. Accurately record location of utilities remaining, rerouted utilities, new utilities by horizontal dimensions, elevations or inverts, and slope gradients.

1.04 PROTECTION

- A. Protect trees, shrubs, lawns, rock outcropping, and other features remaining as portion of final landscaping.
- B. Protect benchmarks, existing structures, fences, roads, sidewalks, paving and curbs.
- C. Protect above or below grade utilities which are to remain.
- D. Repair damage.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. Topsoil: Excavated material, graded free of roots, rocks larger than one inch, subsoil, debris, and large weeds.
- B. Subsoil: Excavated material, graded free of lumps larger than 6 inches, rocks larger than 3 inches, and debris.

PART 3 - EXECUTION

3.01 PREPARATION

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

- B. Identify known below grade utilities. Stake and flag locations. Pothole to determine vertical locations at crossings as indicated on drawings.
- C. Identify and flag above grade utilities.
- D. Maintain and protect existing utilities remaining which pass-through work area.
- E. Upon discovery of unknown utility or concealed conditions, discontinue affected work; notify A/E Professional.

3.02 TOPSOIL EXCAVATION

- A. Excavate topsoil from areas to be further excavated, re-landscaped, or re-graded and stockpile in area designated on site. Remove excess topsoil not being reused from site.
- B. Do not excavate wet topsoil.
- C. Stockpile topsoil to depth not exceeding 10 feet. Cover to protect from erosion.

3.03 SUBSOIL EXCAVATION

- A. Excavate subsoil from areas to be re-landscaped or re-graded and remove excess subsoil not being reused from site.
- B. Do not excavate wet subsoil.
- C. Stockpile subsoil to depth not exceeding 8 feet.
- D. When excavation through roots is necessary, perform work by hand and cut roots with a sharp axe.

3.04 TOLERANCES

- A. Top Surface of Subgrade: Plus, or minus one inch.

END OF SECTION 312213

SECTION 312219 - FINISH GRADING

PART 1 - GENERAL

1.01 WORK INCLUDED

- A. Finish grade subsoil.
- B. Furnish, place, level, and compact topsoil.

1.02 RELATED WORK

- A. Section 312213 - Rough Grading.
- B. Section 312333 - Trenching and Backfilling.
- C. Section 321313 – Concrete Paving.

1.03 PROTECTION

- A. Protect landscaping and other features remaining as final work.
- B. Protect existing structures, fences, roads, sidewalks, paving and curbs.

1.04 QUALITY ASSURANCE

- A. Provide and pay for materials testing. Testing agency shall be acceptable to HG and/or Owner's Geotechnical Consultant (OGC). Provide the following data:
 - 1. Test representative materials samples proposed for use.
 - 2. Topsoil:
 - a. pH factor.
 - b. Mechanical analysis.
 - c. Percentage of organic content.
 - d. Recommendations on type and quantity of additives required to establish satisfactory pH factor and supply of nutrients to bring nutrients to satisfactory level for planting turf and shrubs, mechanical composition, and organic composition of topsoil.
 - e. Conductivity
 - f. Anions: Sulfur, Phosphorus, Nitrate-N
 - g. Cations: Potassium, Calcium, Magnesium, Sodium
 - h. Minor Elements: Iron, Zinc, Manganese, Copper, Boron, Aluminum
 - i. Physical Aspects: USDA Soil Classification, Percent Gravel, Percent Sand, Percent Silt, Estimated infiltration rate (metric per hour)
 - j. Provide confirmation that all imported soils meet criteria listed in Part 2 of this Section.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. Topsoil shall be SIFTED, friable loam; free of subsoil, roots, grass, excessive amount of weeds, stone over 1/2" in any dimension, and foreign matter; acidity range (pH) of 5.5 to 7.5; containing a minimum of 4 percent and a maximum of 25 percent organic matter. Topsoil obtained and prepared on site, or off site if necessary. Provide imported topsoil as required to complete the work.
- B. Imported soils shall comply with the following criteria:
 - 1. Original function is comparable to reuse function.
 - 2. Source location not classified as prime farmland, unique farmland or farmland of statewide or local importance.
 - 3. Not extracted from a greenfield site.
 - 4. Not sphagnum peat moss.

PART 3 - EXECUTION

3.01 INSPECTION

- A. Verify site conditions and note irregularities affecting work of this Section.
- B. Beginning work of this Section means acceptance of existing conditions.

3.02 SUBSOIL PREPARATION

- A. Eliminate uneven areas and low spots. Remove debris, roots, branches, stones, in excess of one inch in size. Remove subsoil contaminated with petroleum products.
- B. Scarify or rip subgrade to depth of 4 inches where topsoil is scheduled. Scarify or rip soil in areas where equipment used for hauling and spreading topsoil has compacted subsoil (6-inch minimum depth is required).

3.03 PLACING TOPSOIL

- A. Amend topsoil to meet the requirements of drawings and specifications.
- B. Place topsoil in areas where seeding, sodding, and planting is scheduled.
- C. Use topsoil in relatively dry state. Place during dry weather.
- D. Fine grade topsoil eliminating rough or low areas. Maintain levels, profiles, and contours of subgrade. Provide positive drainage.
- E. Remove stone, roots, grass, weeds, debris, and foreign material while spreading.
- F. Manually spread topsoil around trees, plants, building and new work to prevent damage.
- G. Lightly compact placed topsoil.
- H. Remove surplus subsoil and topsoil from site.

I. Leave stockpile area and site clean and raked, ready to receive landscaping.

3.04 TOLERANCES

A. Top of Topsoil: Plus, or minus 1/2 inch.

3.05 SCHEDULE OF LOCATIONS

A. See Landscape Plan for compacted topsoil thickness for various locations.

END OF SECTION 312219

SECTION 312316 - EXCAVATION

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Excavation for slabs-on-grade, paving and landscaping.

1.02 RELATED SECTIONS

- A. Section 312333: Trenching and Backfilling
- B. Section 313000: Earthwork

1.03 FIELD MEASUREMENTS

- A. Verify that survey benchmark and intended elevations for the Work are as indicated.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

3.01 EXCAVATION

- A. Underpin adjacent structures which may be damaged by excavation work, including utilities and pipe chases.
- B. Excavate subsoil required to accommodate footings, slabs-on-grade, paving, site structures and construction operations and per requirements of 312000 EARTHWORK.
- C. Grade top perimeter of excavation to prevent surface water from draining into excavation.
- D. Hand trim excavation. Remove loose matter.
- E. Remove lumped subsoil, boulders, and rock up to 6 inches.
- F. Notify HG and Owner's Geotechnical Consultant (OGC) of unexpected subsurface conditions and discontinue affected Work in area until notified to resume work.
- G. Correct unauthorized excavation at no extra cost to Owner.
- H. Correct areas over-excavated by error at no extra cost to Owner.
- I. Stockpile excavated material in area designated on site and remove excess material not being reused from site.

3.02 FIELD QUALITY CONTROL

- A. Provide for visual inspection of bearing surfaces.

3.03 PROTECTION

- A. Protect excavations by methods required to prevent cave-in or loose soil from falling into excavation.
- B. Protect bottom of excavations and soil adjacent to and beneath foundation, from freezing.

END OF SECTION 312316

SECTION 312333 - TRENCHING AND BACKFILLING

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Excavate trenches as shown on drawings.
- B. Compacted bedding under fill over utilities to subgrade elevations.
- C. Backfilling and compaction.
- D. Fill under slabs-on-grade and paving.
- E. Fill for over-excavation.

1.02 REFERENCES

- A. ANSI/ASTM C136 - Method for Sieve Analysis of Fine and Coarse Aggregates.
- B. ANSI/ASTM D698 - Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400ft-lbf/ft³)
- C. ANSI/ASTM D1556 - Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.
- D. ANSI/ASTM D1557 - Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000ft-lbf/ft³)

1.01 FIELD MEASUREMENTS

- A. Verify that survey benchmark and intended elevations for the Work are as shown on Drawings.

PART 2 - PRODUCTS

2.01 BED MATERIALS

- A. Type 1 - Crushed Stone or Gravel free of shale, clay, friable material, sand, debris; graded in accordance with ANSI/ASTM C136.
- B. Type 2 - Pea Gravel: Natural stone; washed, free of clay, shale, organic matter; graded in accordance with ANSI/ASTM C136.
- C. Type 3 - Sand: Natural river or bank sand; washed; free of silt, clay, loam, friable or soluble materials; or organic matter; graded in accordance with ANSI/ASTM C136.
- D. Subsoil: Reused or Imported, free of gravel larger than 3-inch size debris.
- E. Concrete: Lean concrete with a compressive strength of 2500 psi.

2.02 FILL MATERIALS

- A. Type A - Crushed Stone: free of shale, clay, friable material, sand, debris; graded in accordance with ANSI/ASTM C136.
- B. Type B - Pea Gravel: Natural stone; washed, free of clay, shale, organic matter; graded in accordance with ANSI/ASTM C136.
- C. Type C - Sand: Natural river or bank sand; washed, free of silt, clay, loam, friable or soluble materials or organic matter; graded in accordance with ANSI/ASTM C136.
- D. Type D – VDOT 21A stone.
- E. Type E - Structural Fill.
- F. Type F - Soil Cement.
- G. Subsoil: Reused or imported, free of gravel larger than 3 inch size, and debris.
- H. Concrete: Lean concrete with a compressive strength of 2500 psi.

2.03 ACCESSORIES

- A. Geotextile Fabric: as noted on drawings.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Verify fill materials to be reused are acceptable per Owner's Geotechnical Consultant, Geotechnical Report and/or 312000 Earthwork specification.
- B. Verify foundation perimeter drainage installation has been inspected.

3.02 PREPARATION

- A. Identify required lines, levels, contours, and datum.
- B. Maintain and protect existing utilities remaining, which pass through work area.
- C. Protect plant life, lawns, rock outcropping and other features remaining as a portion of final landscaping.
- D. Protect benchmarks, existing structures, fences, sidewalks, paving, and curbs from excavation equipment and vehicular traffic.
- E. Protect above and below grade utilities which are to remain.
- F. Generally, compact subgrade to density requirements for subsequent backfill materials.

- G. Cut out soft areas of subgrade not capable of insitu compaction. Backfill with Type E fill and compact to density equal to or greater than requirements for subsequent backfill material.
- H. Prior to placement of aggregate base course material at gravel paved areas, compact subsoil per 31 2000 Earthwork listed maximum dry density in accordance with ANSI/ASTM D698.

3.03 EXCAVATION

- A. Excavate subsoil required for specified utilities.
- B. Cut trenches sufficiently wide to enable installation of utilities and allow inspection.
- C. Excavation shall not interfere with normal 45 degree bearing splay of foundations.
- D. Hand trim excavation. Hand trim for bell and spigot pipe joints. Remove loose matter.
- E. Remove lumped subsoil, boulders, and rock up to 1/3 cu. yd., measured by volume. Larger material will be removed under Section 31 2316.
- F. Correct unauthorized excavation at no cost to Owner.
- G. Correct areas over-excavated by error in accordance with Section 31 2316.
- H. Stockpile excavated material in area designated on site and remove excess material not being used, from site.

3.04 BEDDING

- A. Support pipe during placement and compaction of bedding fill.

3.05 BACKFILLING

- A. Backfill areas to contours and elevations with unfrozen 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 shown prior to placing next lift of fill.
- D. Granular Stone Fill: Place and compact materials in continuous layers not exceeding 6 inches compacted depth.
- E. Soil Cement Fill: Place and compact materials in continuous layers not exceeding 6 inches compacted depth.
- F. Select Soil Fill: Place and compact material in continuous layers not exceeding 6 inches compacted depth.
- G. Employ a placement method that does not disturb or damage foundation perimeter drainage, waterproofing protective cover, and utilities in trenches.
- H. Maintain optimum moisture content of backfill materials to attain required compaction density.

- I. Backfill against supported foundation walls.
- J. Backfill simultaneously on each side of unsupported foundation walls.
- K. Slope grade away from site walls minimum 2 inches in 10 ft., unless noted otherwise.
- L. Make grade changes gradual. Blend slope into level areas.
- M. Remove surplus backfill materials from site.
- N. Leave fill material stockpile areas completely free of excess fill materials.

3.06 TOLERANCES

- A. Top Surface of Backfilling Under Paved Areas: Plus, or minus one-half inch from required elevations.
- B. Top Surface of General Backfilling: Plus, or minus one inch from required elevations.

3.07 FIELD QUALITY CONTROL

- A. Field inspection and testing will be performed under provisions of Section 01 4000.
- B. Tests and analysis of fill material will be performed in accordance with ANSI/ASTM D698.
- C. Compaction testing will be performed in accordance with ANSI/ASTM D1556, ANSI/ASTM D698.
- D. If tests indicate Work does not meet specified requirements, remove Work, replace and retest at no cost to Owner.
- E. Frequency of Tests: 2 times.
- F. Proof roll compacted fill surfaces under slabs-on-grade and pavers.

3.08 PROTECTION OF FINISHED WORK

- A. Protect finished Work.
- B. Recompact fills subjected to vehicular traffic.

3.09 SCHEDULE

- A. Compaction percentages as listed in 312000 EARTHWORK shall apply.

END OF SECTION 312333

SECTION 312500 - EROSION AND SEDIMENTATION CONTROLS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This Section specifies requirements for temporary and permanent erosion and sedimentation control provisions as they relate to the construction process. Contractor shall conform to the requirements written into the Virginia Construction General Permit VAR10. In the event of conflicting direction, whichever of this specification or the Construction General Permit is more stringent shall apply.
- B. The work includes:
1. Providing and maintaining all temporary erosion and sedimentation control measures shown on the Drawings and required by the Engineer during the life of the Contract to control soil erosion and water pollution.
 2. The installation and maintenance of additional silt fence, berms, ditches, sedimentation basins, construction exits, fiber mats, catch basin filters, straw, netting, gravel, trenches, mulches, grasses, slope drains, and other approved erosion control devices or methods, needed to protect any areas on or off site.
 3. Maintaining the Stormwater Pollution Prevention Plan booklet.

1.2 DEFINITION AND COORDINATION OF EROSION AND SEDIMENTATION CONTROL PROVISIONS

- A. Permanent erosion and sedimentation control measures are defined as those elements that are to be incorporated into the final project product, including but not necessarily limited to such items as: finish paving and landscape, stormwater pre-treatment structures, swales and ditches, berms, and other such items.
- B. Temporary erosion and sedimentation control measures are defined as those elements that are required by permit approvals and necessary to be installed by the Contractor to meet federal, state and local regulations for the construction program, including, but not necessarily limited to, such items as: silt fences, berms, hay bales, check dams, and other such items, all of which shall be removed by the Contractor after installation of permanent erosion and sedimentation control measures, stabilization of the site, and prior to final completion of the project.
- C. The temporary control provisions shall be coordinated with the permanent erosion and sedimentation control features to the extent practical to ensure economical, effective, and continuous erosion and sedimentation controls throughout the construction and post-construction periods.

1.3 LAWS AND REGULATIONS

- A. Compliance with the EPA NPDES Storm Water Regulations (VSMP/Construction General Permit through DEQ) is the responsibility of the Contractor.

1.4 PRIOR TO CONSTRUCTION

- A. Prior to the start of the construction, the Contractor shall submit to the Engineer the following: schedules for the construction of required temporary and permanent erosion and sediment control work, clearing and grubbing, grading, and paving. No work shall be started until control schedules and methods of operations have been submitted to the Engineer.

1.5 CONSTRUCTION OPERATIONS

- A. When in the opinion of the City of Colonial Heights Inspector it becomes necessary, the Inspector will inform the Contractor of construction procedures and operations that jeopardize erosion and sedimentation control provisions. If these construction procedures and operations are not corrected promptly, the Owner or the Inspector may suspend the performance of any or all construction until corrections have been made, and such suspension shall not be the basis of any claim by the Contractor for additional compensation from the Owner nor for an extension of time to complete the Work.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Temporary erosion control seed for quick growing grasses such as wheat, rye or oats shall be planted only when permanent grasses cannot be planted due to the growing season. All permanent grass areas planted with temporary erosion control seed shall be replaced with permanent seed. Apply seed mixture at a rate of 100 pounds per acre. Seed mix shall be in accordance with the Virginia Erosion and Sediment Control Handbook.
- B. Erosion Control Blanket/Fabric Netting shall be provided on all slopes of 1 foot rise to 2 feet and steeper and shall consist of undyed and unbleached smolder resistant jute yarn woven into a uniform, open, plain weave mesh. Jute matting shall be furnished in rolled strips and shall conform to the following:
 - 1. Width: 48 inches, plus or minus one inch.
 - 2. 78 warp ends per width of cloth.
 - 3. 41 weft ends per yard.
 - 4. Weight: To average between 1.22 lbs. and 1.80 lbs. per linear yard.
 - 5. Tolerance: plus or minus 5%

PART 3 - EXECUTION

3.1 TEMPORARY EROSION CONTROL MATS

- A. Erosion control mats shall be installed in accordance with the manufacturer's recommendations.
- B. Areas to receive mats shall be smooth graded and compacted. Remove all rocks, dirt clods, vegetation, and other obstructions that may cause damage to the mats.

- C. Unroll mats parallel to the direction of water flow and lay flat against the ground. Overlap roll ends a minimum of 1 foot with upslope mat on the top to prevent uplift of mat end by water flow. Overlay adjacent edges of mat by six (6) inches. Extend mat a minimum of 2 feet above the crest of steep slopes and anchor by excavating a 6 inch deep trench, and secure end of mat in trench using staples or pins furnished by manufacturer of mat. After securing mat end in place, backfill and compact trench.

3.2 SILT FENCE

- A. Silt fence shall be installed at locations as shown on the Drawings.
- B. Supporting posts shall be spaced 4 feet on center, and driven at least 1 foot into the ground. Posts shall be 1-1/2 inch square or heavier wood posts or standard steel posts.
- C. Fabric shall be anchored in a 4-inch deep trench dug on the upslope side of the posts. The trench shall be at least 4 inches wide. The fabric shall be laid in the trench, backfilled, and compacted.
- D. Fabric rolls shall be spliced at posts. The fabric shall be overlapped 6 inches, folded over, and then securely fastened to posts.
- E. Silt fences shall be inspected immediately after each storm event and at least daily during prolonged rainfall.

3.3 CONSTRUCTION REQUIREMENTS - TEMPORARY EROSION AND SEDIMENTATION CONTROL

- A. The Contractor shall construct all permanent erosion and sedimentation control features at the earliest practical time as outlined in the accepted schedule. Temporary erosion and sedimentation control measures shall be used to correct conditions that develop during construction which were unforeseen but are needed prior to installation of permanent erosion and sedimentation control features, or that are needed temporarily to control erosion or sedimentation which develops during construction operations.
- B. Where erosion is likely to be a problem, clearing and grubbing operations shall be scheduled and performed so that grading operations and permanent erosion and sedimentation control features can follow immediately thereafter, if conditions permit; otherwise, temporary erosion and sedimentation control measures will be required between successive construction stages.
- C. Contractor shall be responsible for controlling erosion within the project area and retaining sediment on-site away from sensitive environmental resources. Any fines, construction delays, remedial actions, or incarceration resulting from the Contractor's failure to comply with these provisions shall be the responsibility of the Contractor and not the Owner.
- D. Failure by the Contractor to control erosion, pollution, and siltation shall be cause for the Owner to employ outside assistance to provide the necessary corrective measures. The cost of such assistance, including engineering costs, will be charged to the Contractor and appropriate deductions made from the Contractor's monthly progress payment.

- E. The Contractor shall remove and properly dispose of sediment from control facilities. The Contractor shall modify and improve erosion and sedimentation control facilities and replace deteriorated hay bales and other devices as needed or as required by the Inspector.
- F. Minimum temporary and permanent erosion and sedimentation control measures are shown on the Drawings. The Contractor shall strictly adhere to the minimum provisions shown. Additionally, temporary measures shall be selected and constructed by the Contractor in consultation with the Engineer or Inspector to accommodate changing field conditions that develop during construction.
- G. Per NPDES Permit requirements, in disturbed areas where construction has permanently or temporarily ceased, the area must be stabilized within 14 days. If earth-disturbing activities will resume within 14 days, temporary stabilization is not required.
- H. All disturbed areas shall be re-vegetated by loaming and seeding unless otherwise noted on the approved plan.

3.4 MAINTENANCE OF EROSION AND SEDIMENTATION CONTROL MEASURES

- A. The Contractor shall check the condition of erosion and sedimentation control devices daily and maintain them in good operating condition.
- B. The Contractor shall inspect the condition of erosion and sedimentation control devices after each rainstorm and during major storm events. Repairs shall be made as necessary.
- C. During construction, temporary outlets of the drainage systems shall direct the flow to temporary or permanent sedimentation basins.
- D. Temporary soil erosion and sedimentation control devices shall be removed and adjacent areas outside the limits of grading restored upon completion of the work and with permission of the Inspector.

END OF SECTION 312500

SECTION 321220 - AGGREGATES

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. Aggregate base course.
 - 2. Open graded stone or surface course.
 - 3. Porous stone.

1.3 REFERENCES

- A. Comply with applicable requirements of the following standards. In the event these standards conflict with other specified requirements, the most restrictive requirement governs.
 - 1. American Society for Testing and Materials (ASTM):
 - a. C 33: Concrete Aggregates
 - b. C 136: Sieve Analysis of Fine and Coarse Aggregates
 - c. D 422: Particle - Size Analysis of Soils
 - d. D 698: Laboratory Compaction Characteristics of Soils Using Standard Effort
 - e. D 1556: Density of Soils by the Sand Cone Method
 - f. D 1557: Laboratory Compaction Characteristics of Soils Using Modified Effort
 - g. D 2216: Laboratory Determination of Water Content of Soil and Rock
 - h. D 2922: Density of Soil and Soil - Aggregate in Place by Nuclear Methods (shallow depth)
 - i. D 3017: Moisture Content of Soil and Soil Aggregate In Place by Nuclear Methods (shallow depth)
 - j. D 4318: Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
 - 2. Occupational Safety and Health Administration (OSHA).
 - 3. VDOT Standard Specifications.

1.4 INFORMATIONAL SUBMITTALS

- A. Certifications of Laboratory Test Reports:
 - 1. Provide certifications stating that the material complies with the requirements indicated on the Drawings and within this Section.

B. Field Test Results:

1. Provide Results of field density tests of in-place material.

1.5 QUALITY ASSURANCE

- A. Provide all aggregates as specified in the Section, unless otherwise indicated on the Drawings.
- B. Submit laboratory test reports to the Designer.
- C. Provide field density reports of in-place material.

1.6 PRODUCT DELIVERY AND STORAGE

- A. Deliver and store all materials within the Contractor's work limits or in an area approved by the Designer.

1.7 REGULATORY REQUIREMENTS

- A. Regulatory Requirements: Unless otherwise indicated, comply with materials, workmanship, and other applicable requirements of Virginia Department of Transportation Standard Specifications for Roads and Bridges for aggregates.
 1. VDOT Specifications: Virginia Department of Transportation Standard Specifications for Roads and Bridges.
- B. Delivery and storage of aggregate to comply VDOT Standard Specification Section 200.

PART 2 - PRODUCTS

2.1 AGGREGATE BASE COURSE

- A. 21-A Type II Aggregate: Comply with VDOT Specifications Section 208 for base course under pavement.
- B. Gradation Acceptable Ranges:

1.	<u>Sieve size</u>	<u>Percent Passing by Weight</u>
	2"	100
	1"	94-100
	3/8"	63-72
	No. 10	32-41
	No. 40	14-24
	No. 200	6-12

2. In addition to the gradation acceptance requirements listed in Table above, the material passing the No. 40 sieve must not have a liquid limit in excess of 30 nor a plasticity index in excess of 6. If any individual test results indicate values exceeding these, the Designer may reject the entire lot.
3. For each sampling unit, two random samples will be taken. The average gradation test results of these samples will be used to determine the acceptability of the unit.
4. When a unit fails to meet the specification requirements of Article 10103(B) the unit represented must be removed from the stockpile or covered by spreading the required amount of corrective material over the surface of the unit. Correction will not be allowed when the amount of corrective material required exceeds 5 inches depth in which case the unit will be rejected and shall be removed from the stockpile. (See Standard Special Provisions.)

2.2 FINE AGGREGATE (Surface Course)

- A. Fine aggregate grading A for use in hydraulic cement concrete, mortar, asphalt concrete, and asphalt surface treatments per VDOT Section 202:

1.	<u>Sieve Size</u>	<u>Percent Passing by Weight</u>
	3/8"	min. 100
	No.4	95-100
	No.8	80-100
	No.16	50-85
	No. 50	5-30
	No. 100	Max. 10

2. Fine aggregates for use in hydraulic cement concrete that are obtained from more than one sources shall not be used alternately or mixed without the consent of the engineer.
3. In addition to the gradation acceptance requirements listed in Table above, the material must meet all of the testing requirements of VDOT Section 202.03.

2.3 POROUS STONE

A. Porous Stone: Comply with the following gradation per VDOT Section 204:

1. Sieve Size	Percent Passing by Weight
3/8"	100
No. 4	95 – 100
No. 8	85 – 100
No. 16	45 - 95
No. 30	25 - 65
No. 50	5 - 40
No. 100	1 - 10
No. 200	0 – 5

Any references to VDOT #57 stone, or #57 stone, intend angular stone.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Provide aggregates to the limits and dimensions as indicated on the Drawings.
- B. General Compaction Requirements: Provide the following general compaction requirements unless more stringent compaction requirements are indicated:
1. General Applications: 90% minimum.
 2. Bedding and Pipe Backfills: 95% minimum.
 3. Structural Backfills: 95% minimum.
 4. Structural Bases and Subbases: 98% minimum; ASTM D 698.
- C. Regulate loose lift thickness by the compaction equipment used to produce the above minimum standards. The maximum allowable lift thickness must not exceed 8 inches with the exception of an initial "bridging" lift used only where indicated or allowed by the soil conditions and as approved by the Designer. Normal lift thickness must be in a range of 6 to 8 inches and conform to the industry standard that the maximum aggregate size particle cannot exceed 2/3 of the loose lift thickness.

3.2 TESTING

- A. Perform applicable testing conforming to the standards of the American Society for Testing and Materials (ASTM) prior to the delivery or incorporation of the material specified herein, unless otherwise indicated. Submit test results to HG.
- B. Provide certification issued by the testing agency or supplier indicating the materials meet the requirements and conform to applicable standards of the VDOT Specifications.

- C. Conduct suitable in-place testing upon installation of the materials to confirm adequate compaction and quality control results.
 - 1. Perform required field density tests: Comply with ASTM D 1556, ASTM D 2922, or ASTM D 3017.
 - a. For Gravel Pavement: Provide one field density test for every 10,000 sq. ft. per lift layer or a minimum of three (3) tests per work zone.
 - b. For All Other Applications: Provide field density test for appropriate area as referenced in Section 31 2000 – EARTHWORK.

END OF SECTION 321220

SECTION 321313- CONCRETE PAVING

PART 1 - GENERAL

1.1 SUMMARY

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification sections, apply to this section.
- B. This Section specifies requirements for hydraulic cement concrete on the site, including formwork, reinforcement, concrete materials, mixture design, placement procedures, and finishes, for the following:
 - 1. Concrete pavements.
 - 2. Concrete curbs.
 - 3. Concrete walks.
 - 4. Joints
 - 5. Caulking.

Refer to 033055 Cast In Place Concrete (Site) for posts, foundations, and/or small site retaining walls/footings if applicable.

1.2 QUALITY ASSURANCE

- A. Unless otherwise indicated in specification or plan, materials and methods of construction shall comply with the following standards:
 - 1. Virginia Department of Transportation (VDOT), Road and Bridge Specifications.
 - 2. American Society for Testing and Materials, (ASTM).
 - 3. American Concrete Institute, (ACI).
- B. Obtain each type or class of cementitious material of the same brand from the same plant; obtain aggregate from a single source; and obtain sealants and admixtures from a single source/manufacturer.
- C. Installer shall be ACI-certified Flatwork Technician and Finisher.
- D. Manufacturer shall be certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities," shall be experienced in manufacturing ready-mixed concrete products and shall comply with ASTM C94/C 94M requirements for production facilities and equipment.

1.3 SUBMITTALS

- A. Design Mixture for each concrete mixture type: preferred format VDOT Materials Division Statement of Hydraulic Cement Concrete Mix Design. Obtain approval before placing concrete.
- B. Submit manufacturer's product data/material certificates signed by manufacturer for all materials used.
- C. Construction joint layout and pour schedule. Location of joints subject to approval by HG.

- D. Joint sealant samples for color selection. Submit manufacturer's full range of colors for joint sealants to match the appearance of exposed surfaces; HG and owner must confirm color choice prior to ordering material.

1.4 TESTING

- A. The Owner shall engage the services of the concrete testing laboratory to perform the sampling, cylinder preparation and delivery, testing, and reporting. The Contractor shall be responsible for adequate advance notice to the testing laboratory for the contractor's concrete pours/placement.
- B. When requested, Contractor shall prepare test specimens in accordance with ASTM C31, standard cylinder size 4-inch x 8 inch.
- C. Testing of materials and installed work may occur at any time during progress of the work. Rejected materials and installed work shall be removed and replaced.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, and handle steel reinforcement to prevent bending and damage.
- B. Store waterstops under cover to protect from moisture, sunlight, dirt, oil and other contaminants.

1.6 PROJECT CONDITIONS

- A. Work notification: Notify HG at least 24 hours prior to installation of concrete.
- B. Establish and maintain required lines and grade elevations.
- C. Do not install concrete work over wet, saturated, muddy, or frozen subgrade.
- D. Do not install concrete when air temperature is below 40 degrees F or above 95 degrees F. Use of calcium chloride, salt, or any other admixture to prevent concrete from freezing is prohibited.
- E. Protect adjacent work.
- F. Provide temporary barricades and warning lights as required for protection of project work and public safety.

PART 2 - PRODUCTS

2.1. STEEL REINFORCEMENT AND ACCESSORIES

- A. Steel reinforcing bars: ASTM A615, Grade 60, deformed.
- B. Steel Wire: ASTM A82, plain cold drawn steel.
- C. Welded Wire Fabric (WWF) Reinforcement: Welded wire fabric reinforcement shall conform to the applicable requirements of ASTM A185. Fabric reinforcement shall be furnished in flat sheets. Fabric reinforcement in rolls will not be permitted.
- D. Joint Dowel Bars: ASTM A 615, Grade 60, plain-steel bars cut true to length with ends square and free of burrs.

- E. Supports for Reinforcement: Bolsters, chairs, and other devices for spacing, supporting, and fastening reinforcing bars and welded wire fabric in place shall be wire bar-type supports complying with CRSI Manual of Standard Practice.
 - a. For slabs-on-grade, use supports with sand plates or horizontal runners where base material will not support chair legs.
 - b. For exposed-to-view concrete surfaces where legs of supports are in contact with forms, provide supports with legs that are protected by plastic (CRSI Class 1) or CRSI Class 2 stainless-steel bar supports.

2.2 MATERIALS

- A. Cementitious material, Portland Cement alone or in combination with one of the following: blended hydraulic cement, fly ash and other pazzolans, ground granulated blast-furnace slag, and silica fume. In combination, shall conform to ASTM C595 / AASHTO M240. Use the same type, brand, and source throughout the project.
 - 1. Portland Cement: ASTM C150, Type I/II
 - a. Type I to be used if no sulfates in soil, Type II to be used if sulfates in soil
 - b. Type III may be used with HG's approval if high early strength is necessary for project schedule.
 - 2. Fly Ash: ASTM C618, Class F
 - 3. Ground Granulated Blast-Furnace Slag: ASTM C989, Grade 100 or 120
 - 4. Silica fume: ASTM C1240 / AASHTO M307
- A. Fine and Coarse Aggregates from a single source throughout the project conforming to ASTM C33.
 - 1. Maximum coarse-aggregate size of 1-inch nominal meeting Class 3S or better graded.
 - 2. Coarse aggregate for concrete shall be crushed granite or approved equal.
 - 3. Fine aggregate shall be free of materials with deleterious reactivity to alkali in cement.
- B. Water
 - 1. Use public potable water supply.
 - 2. Clear and free from injurious substances.
- C. Admixtures
 - 1. Water reducing - ASTM C494, Type A / AASHTO M194, Type D and shall be free from water-soluble chlorides. Admixture must be tested for compatibility with the brand, type, source and quantity of cement proposed for use.
 - 2. Air entraining - ASTM C260 / AASHTO M154
 - 3. Accelerating – C494 / AASHTO M194, Type C or Type E
 - 4. Calcium chloride – AASHTO M144, Type 2
- D. Grout: All grout shall be non-shrink, non-metallic, non-gas forming, pre-blended and ready for use requiring only the addition of water.

2.3 MIXES

- A. Prepare design mixtures for each type and strength of concrete, proposed on the basis of laboratory trial mixture, field test data, or both, according to ACI 301. If using cementitious material additives, mix designer must have experience in mixing, proportioning, placement procedures and curing of concrete containing alternative materials in conjunction with Portland cement. Cementitious materials other than Portland cement shall be limited as follows, percentage by weight:
 - 1. Fly Ash: 20% for Total Alkalies of Cement $\leq 0.75\%$; 25% for Total Alkalies of Cement $>0.75\%$ and $\leq 1.0\%$ (max. 30 percent)
 - 2. Ground Granulated Blast-Furnace Slag: min. 40 percent, max. 50 percent
 - 3. Silica Fume: 7% - 10%
 - 4. Combination of Portland cement substitutes is not permitted.
- B. Provide ASTM C94 ready-mixed concrete, batch mixing at site not acceptable. Compressive strength at 28 days as follows:
 - 1. Walks: 3,000 psi
 - 2. Vehicular concrete/equipment pads: 4,000 psi
 - 3. Curbs: 3,000 psi cast-in-place; 4,000 psi precast
- C. Slump range: 2" to 4" maximum.
- D. Provide an approved water-reducing admixture in all concrete.
- E. Provide an air-entraining admixture in all concrete. Air content 5% to 7%.
- F. Maximum water-cement ratio: 0.49 (0.45 for posts & rails) conforming to ACI 316R.
- G. Indicate water added to mix at job site on each delivery ticket. Show quantity of water added. Site water tempered mixes exceeding specified slump range will be rejected as not complying with specification requirements.
- H. Concrete shall contain no calcium chloride or admixtures containing calcium chloride. No admixtures other than those specified herein or by VDOT shall be used in the concrete without approval of HG.

2.4 CURING MATERIALS

- A. Curing shall be accomplished by the following methods:
 - 1. Moist curing with combination of burlap and polyethylene (PE) film, bonded securely so they cannot be easily separated in a dry or saturated conditions. Burlap per AASHTO M182, Class 3; PE film per AASHTO M171.
 - 2. Curing paper, nonstaining, fiber reinforced laminated Kraft bituminous product conforming to ASTM C171. Four mil PE sheeting may be substituted for curing paper.
 - 3. Curing compound, a resin-base, white pigmented, low VOC compound conforming to ASTM C309, Type 2.
 - 4. Potable water free of oil and other deleterious substances.

2.5 ACCESSORIES

- A. Granular base: VDOT No. 57 uniformly graded, clean crushed, angular stone.

- B. Forms: Wood or metal of sufficient strength to resist concrete placement pressure and to maintain horizontal and vertical alignment during concrete placement. Provide forms straight, free of defects and distortion, and height equal to full depth of concrete work.
- C. Expansion Joints
 - 1. Expansion joint filler: ASTM D1751, pre-molded non-extruding asphalt-impregnated fiberboard, thickness indicated.
 - 2. Pre-molded joint filler shall be one piece for the full depth and width of the joint.
- D. Smooth dowel shall be hot rolled plain steel dowel bonded at one end and operating in a smooth close-fitting sleeve (of same material) at the other. ASTM A 614, Grade 60, cut true to length with ends square and free of burrs.
- E. Reinforcement
 - 1. Welded Wire Fabric (WWF): Welded wire fabric reinforcement shall conform to the applicable requirements of ASTM A185. Fabric reinforcement shall be furnished in flat sheets. Fabric reinforcement in rolls will not be permitted.
 - 2. Steel reinforcing bars: ASTM A615, Grade 60, deformed.
 - 3. Steel Wire: ASTM A82, plain cold drawn steel.
- E. Reinforcing supports
 - 1. Bolsters, chairs, and other devices for spacing, supporting, and fastening reinforcing bars and welded wire fabric in place shall be wire bar-type supports complying with CRSI Manual of Standard Practice.
 - c. For slabs-on-grade, use supports with sand plates or horizontal runners where base material will not support chair legs.
 - d. For exposed-to-view concrete surfaces where legs of supports are in contact with forms, provide supports with legs that are protected by plastic (CRSI Class 1) or CRSI Class 2 stainless-steel bar supports.
- F. Form release agent: Non-staining chemical form release agent free of oils, waxes, and other materials harmful to concrete.
- G. Caulking: ASTM C-920, type I, single component, slope grade, polyurethane caulk. Color to be approved by HG.

PART 3- EXECUTION

3.1 INSPECTION

- A. Examine subgrades and installation conditions. Do not start concrete work until unsatisfactory conditions are corrected.

3.2 PREPARATION

- A. Refer to 31 30 00 Earthwork for subgrade preparation, 321100 Base Courses (Pavement) for base course placement, and 321220 Aggregates for base course materials.
- B. Remove loose material and debris from base surface before placing concrete.

- C. Install, align, and level forms. Stake and brace forms in place. Maintain following grade and alignment tolerances:
 - 1. Top of form: Maximum 1/8" in 10'-0".
 - 2. Vertical face: Maximum 1/4" in 10'-0".
- D. Coat form surfaces in contact with concrete with form release agent. Clean forms after each use and coat with form release agent as necessary to assure separation from concrete without damage.
- E. Locate, place, and support reinforcement as indicated.
 - 1. Before being placed in position, reinforcement shall be thoroughly cleaned of loose mill and rust scale, dirt, ice, and other foreign material which may reduce the bond between the concrete and reinforcing.
 - 2. Provide a single layer of welded wire fabric in all concrete slabs-on-grade where indicated.
 - 3. Provide reinforcing bars at locations indicated, adequately supported and secured to prevent displacement.

3.3 INSTALLATION

- A. Concrete placement:
 - 1. Comply with ACI 304 "Recommended Practice for Measuring, Mixing, Transporting, and Placing Concrete", and as specified.
 - 2. Protect concrete from physical damage or reduced strength due to weather extremes during mixing, placing, and curing. In cold weather comply with ACI 306, "Recommended Practice for Cold Weather Concreting". In hot weather comply with ACI 305, "Recommended Practice for Hot Weather Concreting".
 - 3. Moisten base to provide a uniform dampened condition at the time concrete is placed. Do not form mud or puddles. Verify manholes or other structures are at required finish elevation and alignment before placing concrete.
 - 4. Place and spread concrete to the full depth of the forms. Use mechanical spreader unless hand-spreading is necessary due; use only square-end shovels or concrete rakes for hand-spreading and consolidating concrete. Exercise care during spreading and consolidating operations to prevent segregation of aggregate and dislocation of reinforcement.
 - 5. Place concrete in a continuous operation between expansion joints. Provide construction joints when sections cannot be placed continuously.
 - 6. Place concrete in one course, monolithic construction, for the full width and depth of concrete work.
- B. Joints:
 - 1. Construct control, expansion, and construction joints properly aligned with face perpendicular to concrete surface.
 - 2. Provide tooled control joints, sectioning concrete into areas indicated on plans. Hand tool joints to depth equal to not less than one-fourth (1/4) of the concrete thickness. When not indicated, provide equal spacing between expansion joints, at a minimum spacing equal to slab width and/or not greater than 10'-0" on center. Joints shall be made after concrete is

finished and when the surface is still enough to support the weight of workmen without damage to the slab, but before slab has achieve its final set.

3. Provide standard keyed-section construction joints where indicated on plans and/or as approved in construction joint submittal. Construction joints shall be placed whenever placing of concrete is suspended for more than 30 minutes.
4. Provide expansion joints using pre-molded joint filler at concrete work abutting curbs, walls, structures, walks, and other fixed objects.
 - a. Locate expansion joints as indicated and as described above. When not indicated, provide joints at maximum 30'-0" on center. Align expansion joints in abutting curbs and walks.
 - b. Install joint fillers full-width and depth of joint. Recess top edge ½-inch below finished surface for joint sealant caulk.
 - c. Install steel dowels and sleeves at expansion joints between slabs if/where indicated.
 - d. Provide joint fillers in single lengths for the full slab width, whenever possible. Fasten joint filler sections together when multiple lengths are required.
 - e. Protect the top edge of the joint filler during concrete placement.

C. Concrete finishing:

1. Perform concrete finishing using mechanical or hand methods as required.
 - a. For textured broom finish concrete- upon completion of floating, and after bleed water has disappeared and concrete can sustain foot pressure with nominal indentation, cut concrete away from forms. Work edges with an edging tool. Round edges to 1/2" radius.
 - b. For exposed aggregate finishes- upon completion of floating, and after bleed water has disappeared and concrete can sustain foot pressure with nominal indentation, cut concrete away from forms. Work edges with an edging tool. Round edges to 1/2" radius. Lightly spray away fines to expose aggregate without creating a spray pattern. Go over entire project once. Feather any sand spots or clean up cloudy areas.
 - c. After exposed aggregate is washed and everything looks consistent, spray on water based, low sheen sealer or curing compound per manufacturers specifications.
2. Concrete surfaces shall be screened and finished true to line and grade, and free of hollows and bumps. Surface shall be dense and smooth.
 - a. Finished concrete surface for concrete subbases shall be wood floated to a slightly rough surface. Surface shall not deviate more than 1/4 inch in 10 feet.
 - b. Finished concrete surfaces shall be broom finished, to a uniform surface. Surface shall not deviate more than 1/8 inch in 10 feet.
3. Install control joints at indicated locations during edging operations.
4. Complete surface finish as follows:
 - a. Provide sidewalk and pavement surfaces with textured light broom finish where shown on plan. Edge outside edges and all joints with a radius edging tool. Direction of grooves in concrete surface shall be consistent and perpendicular to direction of travel.

- b. Provide sidewalk and pavement surfaces with washed exposed aggregate finish where shown on plan.

D. Curing:

1. After final finishing, cure by a method below until compressive strength meets or exceeds 90% of the design strength.
 - a. Sheeting—place material on the concrete surface as soon as it is possible without marring the surface. Cover all exposed concrete surfaces and beyond the edge of the concrete surface. Securely tape sheeting together or lap. Maintain the integrity of the material to minimize evaporation loss throughout the curing period. Keep the concrete continuously wet under the sheeting.
 - b. Liquid membrane-forming curing compound—apply curing compounds uniformly and at rate and method recommended by the manufacturer.
 - c. Ponding—build a dike of earth, sand, or other material around the concrete and flood the surface as soon as possible without marring the surface. Replace water lost due to evaporation or leakage at a rate sufficient to maintain the pond. Keep concrete surfaces continuously wet, without a drying/wetting cycle.
 - d. Absorbent material—after final finishing, uniformly distribute nonstaining absorbent materials on the concrete surface without marring the surface. Apply water to the materials, taking care not to displace them. Apply water during the curing period as needed to keep the concrete surfaces continuously wet. Do not allow alternate wetting/drying of concrete surfaces.
 - e. Refer to ACI recommendations for hot weather curing (ACI 305) or cold weather curing (ACI 306) if necessary
2. Termination of curing acceptable when concrete compressive strength meets or exceeds 90 percent of the design compressive strength. Refer to sections 1.4, 2.3B, and 3.4.

E. Caulking:

1. Apply caulking to all expansion joints after concrete curing.
2. Apply per manufacturer's instructions and in temperature ranges acceptable to the manufacturer.

3.4 FIELD QUALITY CONTROL

A. Provide field quality control testing and inspection during concrete operations.

B. Testing:

1. Provide slump test on first load of concrete delivered each day and whenever requested due to changes in consistency or appearance of concrete.
2. Provide air indicator tests and air meter tests for all air-entrained concrete.
3. Strength testing:
 - a. Provide 1 set of 3 test specimens for each 50-cu. yd. placed in any one day. Secure samples in accordance with ASTM C172 and mold specimens in accordance with ASTM C31.

- b. Test 1 specimen at 7 days and 2 specimens at 28 days in accordance with ASTM C39.
- c. Furnish copies of field records and test reports as follows:
 - i. 2 copies to HG
 - ii. 1 copy to Contractor

3.5 PROTECTION

- A. Protect concrete work from damage during curing by construction equipment, material and methods, application of curing procedures, or running water.
- B. Protect concrete work from damage due to construction and vehicular traffic until final acceptance.
- C. Exclude construction and vehicular traffic from concrete pavements until concrete testing indicates compressive strength of at least 90% of design strength.

3.6 CLEANING

- A. Perform cleaning during installation of the work and upon completion of the work. Remove from site all excess materials, debris, and equipment. Repair damage resulting from concrete operations.
- B. Sweep concrete sidewalks and pavement; wash free of stains, discoloration, dirt, and other foreign material immediately prior to final acceptance.

END OF SECTION 321313

SECTION 329113 - PLANTING SOIL PREPARATION

PART 1 – GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Amendment of Existing Soils.
 - 2. Lightweight Growing Media for Planting on Structure.
 - 3. Importation of Topsoil.
- B. Related Sections:
 - 1. Section 312000, Earthwork
 - 2. Section 329119, Planting Area Finish Grading.
 - 3. Section 329200, Turf and Grasses.
 - 4. Section 329300, Plant Material.

1.02 REFERENCES

- A. ASTM – American Society for Testing Materials: D 1557-91 Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort.
- B. USDA – United States Department of Agriculture: Texture Triangle Classification.
- C. ASCE Manuals and Reports on Engineering Practice No. 71, 1990 – “Agricultural Salinity Assessment and Management” published by the American Society of Civil Engineers.

1.03 DEFINITIONS

- A. Backfill: The earth used to replace or the act of replacing earth in an excavation.
- B. Duff Layer: The surface layer of native topsoil that is composed of mostly decayed leaves, twigs, and detritus.
- C. Manufactured Topsoil: Soil produced off-site by homogeneously blending mineral soils or sand with stabilized organic soil amendments to produce topsoil or planting soil.
- D. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. This includes insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. It also includes substances or mixtures intended for use as a plant regulator, defoliant, or desiccant.

- E. Pests: Living organisms that occur where they are not desired, or that cause damage to plants, animal, or people. These include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.
- F. Planting Area: Areas to be planted.
- G. 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.
- H. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is places.
- I. Subsoil: All soil beneath the topsoil layer of the soil profile and typified by the lack of organic matter and soil organisms.
- J. 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.

1.04 SUBMITTALS

- A. Product Data:
 - 1. Chemical Additives.
- B. Test Reports:
 - 1. "Complete Standard Analysis" of existing native surface topsoil's, existing in-place surface soils, and imported or manufactured topsoils indicating the following:
 - a) Half Saturation Percentage.
 - b) PPM dry soil of: NO₃-N, NH₄-N, PO₄-P, K, Ca, Mg.
 - c) pH.
 - d) Sodium Absorption Ratio.
 - e) Salinity Boron.
 - f) Saturation Extract Values of E_{Ce}, Ca-Me/1, Mg-Me/1, Na-Me/1, K-Me/1, B-PPM.
 - g) USDA sieve method classification.
 - h) USDA hydrometer classification.
 - i) Organic content.

- j) Micronutrients.
 - k) Test laboratory's amendment recommendations.
 - l) Copy of the Planting Plan with each composite sample keyed by number to the area from which the composite test sample was taken.
 - m) Import soil source locations.
- 2. Soil Test for Parasitic Nematodes.
 - 3. Soil Test for Herbicide Contamination.
- C. Purchase Documentation:
 - 1. Chemical Amendment Purchase and Delivery Invoices.
 - D. Imported Topsoil Source Documentation:
 - 1. Before delivery of topsoil, submit to Landscape Architect in writing the location of the property from which the topsoil is to be obtained, names, and addresses of Owners, depth to be stripped, and crops grown during past 2 years, if applicable.

1.05 QUALITY ASSURANCE

- A. Regulatory Requirements:
 - 1. Meet requirements of applicable laws, codes, and regulations required by authorities having jurisdiction over Work.
 - 2. Provide for inspections and permits required by federal, state, and local authorities in furnishing, transporting, and installing materials.
- B. Settlement Mock-Up: Mock-up areas of backfill mix at the specified depths and apply irrigation to induce settlement to help determine the amount of settlement which will be caused by irrigation and rain.

1.06 PRODUCT DELIVERY, STORAGE, AND HANDLING

- A. Materials shall be stored in a neat, safe manner, not to exceed the allowable structural capacity of the storage area.
- B. Delivery and Storage of Packaged Material:
 - 1. Deliver packaged material in containers showing weight, analysis, and name of manufacturer.
 - 2. Store packaged material with protection from weather or other conditions which would damage or impair the effectiveness of the product.
 - 3. Packaged material which has become wet, moldy, or otherwise damaged in transit or in storage, will be rejected.

C. Delivery and Storage of Soils:

1. No soil shall be delivered in a frozen or muddy condition or handled with a moisture content in excess of 40 percent.
2. No soil shall be stockpiled within the drip line of existing trees.

1.07 SITE CONDITIONS

A. Environmental Requirements:

1. Do not work soil when moisture content is so great that excessive compaction will occur, nor when it is so dry that dust will form in the air or that clods will not break readily.
2. Apply water, if necessary, to bring soil to an optimum moisture content for tilling.
3. Do not work soil when muddy or frozen.
4. Do not apply chemicals if wind conditions will cause hazardous drift to people or property.

B. Existing Conditions:

1. Prior to commencement of Work, review and clearly mark in field horizontal and vertical locations of public existing underground utilities and structures with respective utility companies.
2. Prior to commencement of work, review and clearly mark in field horizontal and vertical locations of private underground utilities and structures with the Owner.
3. Prior to commencement of work and after review of the Owner's record irrigation documents, clearly mark in the field heads, valve boxes, and other underground equipments, materials, and structures.

PART 2 – PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS AND SUPPLIERS

A. Soil Testing Agency:

1. Virginia Tech Soil Testing Laboratory; www.soiltest.vt.edu
2. Landscape Supply Inc., 12115 Ridgefield Pkwy, Richmond, VA 23233
3. Approved Equal.

2.02 MATERIALS

- A. Soil for Backfill Mix: Soil excavated from planting pits, unless noted otherwise. Refer to Drawings for location and depth of soil to be amended.

- B. Imported Topsoil: If quantity of stockpiled topsoil is insufficient, provide additional topsoil as required to complete Work.
 - 1. Provide new topsoil which is fertile, friable, natural loam surface soil, reasonably free from subsoil, clay lumps, brush, weeds, and other litter, and free of roots, stumps, stones larger than 2 inches in diameter, and other extraneous or toxic matter harmful to plant growth.

 - 2. Obtain topsoil from local sources or from areas having similar soil characteristics to that found at the project site. Obtain topsoil only from naturally, well-drained sites where topsoil occurs in a depth of not less than 4 inches. Do not obtain from bogs or marshes.

- C. Compost: Organic material is to be well-composted humus with the following properties:
 - 1. Humus material shall have an ash content of no less than 8 percent and no more than 50 percent.

 - 2. The pH of the material shall be between 6 and 7.5.

 - 3. The salt content shall be less than 10 millimho/cm at 25 degrees C (ECe less than 10) on a saturated paste extract. If the ECe exceeds 10 millimho/cm, the maximum rate of sue shall not exceed 15 percent by volume. If the concentration of calcium sulfate in the saturation extract is greater than 25 milliequivalent per liter, the maximum level of salinity can be increased 3 millimho/cm at 25 degrees C. units (13 millimho/cm at 25 degrees C).

 - 4. Boron content of the saturated extract shall be less than 1.0 part per million.

 - 5. Silicon content (acid-insoluble ash) shall be less than 20 percent.

 - 6. Calcium carbonate shall not be present if the amendment is to be applied on alkaline soils.

 - 7. Types of acceptable products are composts, manures, mushroom composts, straw, alfalfa, sludge, peat moss, etc. which are low in salts, low in heavy metals, free from weed seed, free of pathogens, and other deleterious materials.

 - 8. Composted wood products are conditionally acceptable (stable humus must be present). Wood-based products which are based on redwood or cedar are not acceptable.

 - 9. Sludge-based materials are not acceptable if the soil already has a high level (toxic level) of zinc, copper, or other heavy metals based on soil analysis.

 - 10. Carbon : Nitrogen ratio shall be less than 25 : 1.

 - 11. The compost shall be aerobic without malodorous presence of decomposition products.

12. The maximum particle size shall be 1/2-inch, 80-percent or more shall pass a No. 4 screen.
13. Maximum total permissible pollutant concentrations in organic amendment in parts per million on a dry-weight basis:

Arsenic:	20
Cadmium:	15
Chromium:	100
Cobalt:	50
Copper:	150
Lead:	100
Mercury:	10
Molybdenum:	60
Nickel:	100
Selenium:	30
Silver:	10
Vanadium:	50
Zinc:	200

Higher amounts of salinity and boron may be present if the soils are to be pre-leached to reduce the excess or if the plant species will tolerate the salinity and/or boron.

D. Coarse Washed Sand:

1. Physical Properties (dry weight basis):

<u>Percent Passing</u>	<u>Sieve Size</u>
100	0.185 inch (0.25 inch)
95	0.093 inch (No 8, 8 mesh)
65	0.055 inch (No. 14, 14 mesh)
50	0.039 inch (No. 18, 18 mesh)
20	0.0195 inch (No. 35, 35 mesh)
5	0.0097 inch (No. 60, 60 mesh)

2. Chemical Properties:

- a) Salinity: The saturation extract conductivity shall not exceed 3.0 millimhos/cm at 25 degrees C.
- b) Boron: The concentration in the saturation extract shall not exceed 1.0 ppm.
- c) Sodium: The sodium absorption ratio (SAR) as calculated from analysis of the saturation extract shall not exceed 6.0.
- d) pH: Neutral

- E. 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, debris, and material harmful to plant growth.

COLONIAL HEIGHTS HIGH SCHOOL RENOVATION/ADDITION
 COLONIAL HEIGHTS, VIRGINIA
 Architect's Project No: 611565

- F. Peat Moss: Finely shredded, brown in color, suitable for horticultural purposes and frequently referred to in the trade as “greenhouse” or “coarse grind”, containing not more than 35-percent moisture by weight in an “as-received” basis.
- G. Coarse Aggregate: 1 1/2-inch x 3/4-inch washed, crushed, hard rock with the following gradation:

<u>Percent Passing</u>	<u>Sieve Size (inches)</u>
100	2
93 ±6	1 1/2
38 ±12	1
11 ±6	3/4
3 ±2	3/8

- H. Perlite: Horticultural Perlite, 6.5 to 7.5 pH.
- I. Potential Inorganic Amendments Required by Accepted Amendment Program:
 1. Ground Limestone: Agricultural limestone containing not less than 85 percent of total carbonate, ground to such fineness that 50 percent will pass No. 1 sieve and 90 percent will past No. 20 sieve.
 2. Dolomite Lime: Agricultural grade mineral soil conditioner containing 35 percent minimum magnesium carbonate and 49 percent minimum calcium carbonate, 100 percent passing No. 65 sieve.
 3. Gypsum: Agricultural grade product containing 80 percent minimum calcium sulfate.
 4. Iron Sulfate (Ferric or Ferrous): Supplied by a commercial fertilizer supplier, containing 20 to 30 percent iron and 35 to 40 percent sulfur.
 5. Potassium Sulfate / Sulfate of Potash: Agricultural grade containing 50 to 53 percent of water-soluble potash.
 6. Ammonium Sulfate: Commercial product containing approximately 21 percent ammonia.
 7. Ammonium Nitrate: Commercial product containing approximately 34 percent ammonia.
 8. Calcium Nitrate: Agricultural grade containing 15 ½ percent nitrogen.
 9. Ureaform: Granular commercial product containing 38 percent nitrogen.
 10. Iso Butyldiene Diurea (IBDU): Commercial product containing 31 percent nitrogen.
 11. Soil Sulfur: Agricultural grade sulfur containing a minimum of 96 percent sulfur.

12. Iron Sequestrene: Geigy Iron Sequestrene 330 Fe.
13. Silicic Acid Calcium: Commercial grade.
14. Diatomaceous Earth: Calcined, 90 percent silica, with approximately 140 percent water absorption capacity by weight.
15. Zeolites: Mineral clinoptilolite with at least 60 percent water absorption by weight.

J. Potential Fertilizers Required by Accepted Amendment Program:

1. Bonemeal: Commercial, raw or steamed, finely ground; a minimum of 1 percent nitrogen and 10 percent phosphoric acid.
2. Single Superphosphate: Commercial product containing 20 to 25 percent available phosphoric acid.
3. 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:
 - a) Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil test reports and approved by the Landscape Architect.
4. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:
 - a) Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil test reports and approved by the Landscape Architect.
5. Chelated Iron: Commercial-grade FeEDDHA for dicots and woody plants, and commercial-grade FeDTPA for ornamental grasses and monocots.

2.03 MIXES

- A. Composition of Planting Pit Backfill Mix *to Establish Bid*. Actual quantities contingent on amendment program determined by the Landscape Architect based on soil test report:
1. Content:
 - a) 3-pounds gypsum per cubic-yard of dry topsoil.
 - b) 2-pounds iron sulfate per cubic yard of dry topsoil.
 - c) 1-pound Ureaform per cubic yard of dry topsoil.
 - d) 1/3-pound Single Superphosphate per cubic yard of dry topsoil.

- e) 1/3-pound Potassium Sulfate per cubic yard of dry topsoil.
- f) 15-percent organic amendment by volume.
- 2. Mixing:
 - a) Mix materials uniformly with dry topsoil in bulk at one area.
 - b) Mix in clean area or machine, free of materials which will contaminate mix.
 - c) Do not mix materials at each planting pit.
- B. Final Composition of Planting Pit Backfill Mix for Installation:
 - 1. Backfill mixes to be determined by the Landscape Architect based on the soil test reports.
 - 2. Backfill mixes may vary based on location on site and plant material.

2.04 SOURCE QUALITY CONTROL

- A. On-Site Topsoil Quality Verification:
 - 1. Meet testing requirements of 3.03.A below.
 - 2. If required, meet testing requirements of 3.03.B and 3.03.C below.
 - 3. Submit test data and amendment recommendations to the Landscape Architect for review and acceptance.
- B. Imported Topsoil Quality Verification:
 - 1. Meet testing requirements of 3.03.A below.
 - 2. If required, meet testing requirements of 3.03.B and 3.03.C below.
 - 3. Submit test data and amendment recommendations to the Landscape Architect for review and acceptance.
 - 4. No imported topsoil shall be placed until test results have been approved by the Landscape Architect and any and all amendments have been made.

PART 3 – EXECUTION

3.02 EXAMINATION

- A. General: Examine site and verify that conditions are suitable to receive Work and that no defects or errors are present which would cause defective installation of products or cause latent defects in workmanship and function.
- B. Subgrade: Verify that the subgrade is at the correct elevation and slope.

- C. Underground Utilities and Structures: Verify that the locations of utilities, structures, and other underground items have been clearly marked.
- D. Notification of Unsuitable Conditions: Before proceeding with Work, notify the Owner in writing of unsuitable conditions.

3.03 PREPARATION

- A. Protection of Existing Conditions:
 - 1. Use every possible precaution to prevent damage to existing conditions to remain such as structures, utilities, plant material, and paved areas on or adjacent to the site of the Work.
 - 2. Provide barricades, fences, or other barriers to protect existing conditions to remain from damage during construction.
 - 3. Do not store materials or equipment, permit burning, or operate or park equipment under the branches of exiting plants to remain.
 - 4. Submit written and photographic notification of damaged plants and structures to the Owner immediately.
- B. Surface Preparation:
 - 1. Inspect soil surface for sticks, oils, chemicals, plaster, concrete, and other deleterious materials.
 - 2. Do Work required to remove and dispose of the deleterious materials.

3.04 SOIL TESTING

- A. Soil Tests to Define Planting Pit Backfill Mix:
 - 1. Take one composite representative topsoil sample from each planting area, defined by the Landscape Architect, of on-site soil.
 - 2. Provide samples to specified Soil Testing Agency.
 - 3. Soil analysis must state percentages of organic matter; gradation of sand, silt, and clay content; cation exchange capacity; sodium absorption ratio; deleterious material; pH; and mineral and plant-nutrient content of the soil.
 - a) Testing methods and written recommendations shall comply with ASCE Manuals and Reports on Engineering Practice No. 71, 1990.
 - b) The soil-testing laboratory shall oversee soil sampling; with depth, location, and number of samples to be taken per instructions from the Landscape Architect. A minimum of three representative samples shall be taken from varied locations for each soil to be used or amended for planting purposes.

4. At least 30 days prior to soil mix Work, submit written "Complete Standard Analysis" soil test report including soil analysis data and amendment recommendations to the Landscape Architect for review.
 - a) Based upon the test results, state recommendations for soil treatments and soil amendments to be incorporated. State recommendations in weight per 1000 sq. ft. or volume per cu. yd. for nitrogen, phosphorus, and potash nutrients and soil amendments to be added to produce satisfactory planting soil suitable for healthy, viable plants.
 - b) 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.
 5. Landscape Architect will determine the final amendment program based on the soil test report.
 6. Final amendment program may differ from the test report amendment recommendations.
 7. Backfill mixes may vary based on location on site and plant material.
- B. Soil Tests for Parasitic Nematodes:
1. Test soils which have been used for agricultural purposes within the prior 12 months for parasitic nematodes.
 2. Soil will be acceptable if the parasitic nematode population is less than 200 per 50 cubic centimeters of soil.
 3. Do not artificially dry soil prior to testing.
 4. Submit written test report to the Landscape Architect.
- C. Soil Tests for Herbicide Contamination:
1. Perform a radish/rye grass growth trial on soils suspected of herbicide contamination.
 2. Submit written test report to the Landscape Architect.

3.05 FIELD QUALITY CONTROL

- A. Planting Pit Backfill Mix Composition Verification:
1. Employ the specified Testing Agency to take samples and perform soil tests to verify conformance of each soil mix composition with the Specifications.
 2. Have the specified Testing Agency determine the locations(s) of samples to be taken.

3. Have the Testing Agency take samples for testing of the first batch mixed, and take samples at 25 cubic yard intervals thereafter.
 4. Submit to the Landscape Architect for review and acceptance "Complete Standard Analysis" and corrective Work recommendations, if required, to meet requirements of the Specifications.
 5. If corrective Work is recommended by the Testing Agency and requested by the Landscape Architect, perform the corrective Work before the commencement of soil mix placement.
 6. After the corrective Work is complete, have the Testing Agency re-test mix(es) and submit to the Landscape Architect for review and acceptance "Complete Standard Analysis" and corrective Work Recommendations, if required, to meet requirements of the Specifications.
 7. Perform the corrective Work followed by testing and submittal of test analysis and recommendations until the Testing Agency indicates that the soil mix(es) meets the requirements of the Specifications.
 8. When the soil test indicates that the soil mix(es) meets the requirements of the Specification the Contractor will receive written notification of acceptance from the Landscape Architect.
 9. Upon receipt of written notification, the Contractor may commence with placement of soil mix(es).
- B. Field Observation Reviews by Landscape Architect: Coordinate and schedule with the Landscape Architect.

END OF SECTION 329113

SECTION 329119 - PLANTING AREA FINISH GRADING

PART 1 – GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Finish Grading of Planting Area Soil Surfaces.
 - 2. Finish Grading of Soil Surfaces of Aggregate Mulch and Wood Chip Mulch Areas.
- B. Related Sections:
 - 1. Section 312000, Earthwork
 - 2. Section 329113, Planting Soil Preparation.
 - 3. Section 329200, Turf and Grasses.
 - 4. Section 329300, Plant Material.

1.02 REFERENCES

- A. ASTM – American Society for Testing Materials: D 1557-91 Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort.

1.03 DEFINITIONS

- A. Soil Subgrade: The soil surface on which amended soil is placed.
- B. Finished Grade: The required final soil surface grade elevations indicated on the Drawings.
- C. Aesthetic Acceptance of Grades: Acceptance by the Landscape Architect in writing of the aesthetic correctness of the contours. Aesthetic acceptance does not address whether an area drains properly, whether an area is at the correct elevation, or whether an area has been compacted properly.
- D. Acceptance: Wherever the terms “acceptance”, “accepted”, or “acceptable” are used herein, they mean acceptance of the Landscape Architect in writing.

1.04 QUALITY ASSURANCE

- A. Finish Grade Smoothness Mock-up:
 - 1. Prepare a 20-foot by 20-foot area of finish graded soil representing the finish graded surface of the planting areas.

2. Locate mock-up on site in a proposed planting area easily referenced by workers performing finish grading operations.
3. Protect accepted mock-up from physical damage and erosion with fencing, canopies, sandbags, or other accepted means until Final Completion.
4. The accepted mock-ups shall be the standard by which finish grading will be judged.

1.05 SITE CONDITIONS

A. Environmental Requirements:

1. Do not work soil when moisture content is so great that excessive compaction will occur, nor when it is so dry that dust will form in the air or that clods will not break readily.
2. Apply water, if necessary, to bring soil to an optimum moisture content for grading.
3. Do not work soil when muddy or frozen.

B. Existing Conditions:

1. Prior to commencement of Work, review and clearly mark in field horizontal and vertical locations of existing public underground utilities and structures with respective utility companies.
2. Prior to commencement of Work, review and clearly mark in field horizontal and vertical locations of private underground utilities and structures with the Owner.
3. Prior to commencement of Work and after review of the Owner's record irrigation documents, clearly mark in the field heads, valve boxes, and other underground equipments, materials, and structures.

PART 2 – PRODUCTS

NOT USED

PART 3 – EXECUTION

3.01 EXAMINATION

- A. General: Examine site and verify that conditions are suitable for finish grading Work, and that no defects or errors are present which would interfere with or cause incorrect finish grading Work to occur.
- B. Excessive Compaction: Verify that the upper 18 inches of planting soil is compacted no more than 75-percent as determined by ASTM D 1557.

- C. Soil Preparation: Verify that subsoil ripping and soil preparation Work is complete.
- D. Notification of Unsuitable Conditions: Before proceeding with Work, notify the Owner in writing of unsuitable conditions.

3.02 PREPARATION

- A. Protection of Existing Conditions:
 - 1. Use every possible precaution to prevent damage to existing conditions to remain such as structures, utilities, irrigation systems, plant material, and paved areas on or adjacent to the site of the Work.
 - 2. Provide barricades, fences, or other barriers to protect existing conditions to remain from damage during construction.
 - 3. Do not store materials or equipment, permit burning, or operate or park equipment under the branches of exiting plants to remain.
 - 4. Submit written and photographic notification of damaged plants and structures to the Owner immediately.
- B. Surface Preparation:
 - 1. Inspect soil surface for sticks, oils, chemicals, plaster, concrete, and other deleterious materials.
 - 2. Do Work required to remove and dispose of the deleterious materials.
- C. Excessively Compacted Areas:
 - 1. Where planting soil has become compacted more than 75-percent relative density per ASTM D 1557, rip soil to an 18 inch depth in two directions perpendicular to each other.
 - 2. Space ripping tines at 18-inches on center.
 - 3. Do not rip soil within 10 feet of the drip line of an existing tree.

3.03 PLACING PREPARED PLANTING SOIL

- A. Refer to Drawings for location and depth of amended soil.

3.04 FIELD ENGINEERING

- A. General:
 - 1. Refer to Drawings for finish grade information.
 - 2. Ensure smooth finish grades with positive surface drainage acceptable to the Landscape Architect. Landscape Architect to approve finish grading.

3.05 FINISH GRADING OPERATIONS

A. General:

1. Grade soil surface with smooth uniform slope between points where elevations are given, and between points where elevations are given and existing grades.
2. Slope finish grades to drain surface water away from buildings, walks, paving, and other structures.
3. Slope finish grades to drain surface water toward catch basins, area drains, or trench drains as shown on the Drawings.
4. Grade soil surface smooth to be free of high and low areas which will inhibit surface drainage.
5. Grade the edges of lawn, perennial, and groundcover soil surfaces along steel edges, paving, and curbs to an elevation 1-inch below the finished surface of the adjacent steel edges, paving, and curbs, unless indicated otherwise.
6. Grade the edges of shrub areas and aggregate mulch area soil surfaces to an elevation 2 inches below the finished surface of the adjacent steel edge, paving, and curbs, unless indicated otherwise.
7. Hand-rake surface using screed boards, stringlines, and laser levels to achieve smooth surfaces acceptable to the Landscape Architect.

B. Excessive Compaction:

1. Take precautions to prevent soil from becoming compacted more than 75 percent as determined by ASTM D 1557.
2. Rip to an 18-inch depth and rototill upper 6 inches of area compacted more than 75 percent, except within 10 feet of existing tree drip lines.

C. Equipment: use equipment of appropriate size and type to achieve the sculptural forms, profiles, and smooth soil surface free of high areas, depressions, and equipment tracks.

D. Depressions and Loose Material: Fill and compact any depression and remove loose material to finish surface true to line and grade, presenting a smooth, compacted, and unyielding surface.

3.06 PLANTING AREA ESTABLISHMENT

A. Loosen subgrade of planting areas to a minimum depth of 8 inches. Remove stones larger than 1-1/2 inches 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 off-site before spreading.

- 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 planting soil in 6 inch lifts to meet finish grades after natural settlement. Do not spread if planting soil or subgrade is frozen, muddy, or excessively wet.
 - a) Spread first 6 inch lift over loosened subgrade. Mix thoroughly into top 4 inches of subgrade. Spread remainder of planting soil.
- B. Finish Grading: Grade planting areas to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.
- C. Apply a minimum 1 inch of irrigation water to induce settlement and melt clods.
- D. Before planting, obtain Landscape Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

3.07 TURF AREA ESTABLISHMENT

- A. Limit turf subgrade preparation to areas to be planted.
- B. Newly Graded Subgrades: Loosen subgrade to a minimum depth of 6 inches. Remove stones larger than 1-1/2 inches 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 off-site before spreading.
 - 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 planting soil in 6 inch lifts to meet finish grades after light rolling and natural settlement. Do not spread if planting soil or subgrade is frozen, muddy, or excessively wet.
 - a) Spread first 6 inch lift over loosened subgrade. Mix thoroughly into top 4 inches of subgrade. Spread remainder of planting soil.
 - b) If turf area is to be planted in sod, 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 as follows:
 1. Remove existing grass, vegetation, and turf. Do not mix into surface soil.

2. Loosen surface soil to a depth of at least 8 inches. Apply soil amendments and fertilizers according to planting soil mix proportions and mix thorough into top 4 inches of soil. Till soil to a homogeneous mixture of fine texture.
 3. Remove stones larger than 1-1/2 inches in any dimension and sticks, roots, trash, and other extraneous matter.
 4. Legally dispose of waste material, including grass, vegetations, 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 finish grading to areas that can be planted in the immediate future.
- E. Moisten prepared area before planting if soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.
- F. Before planting, obtain Landscape Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

3.08 TOLERANCES

- A. Planting and Turf Areas:
1. Grade soil surface to within 0.05 foot of grades indicated on the Drawings, except bring soil surface grades along steel edge, paving, curbs, and other structures to within 0.01 foot of grades indicated on the Drawings.
 2. Transition soil surface grades along steel edge, paving, curbs, and other structures to areas of less strict tolerance over a 5-foot distance.
- B. Aggregate Mulch and Wood Chip Mulch Areas:
1. Grade soil surface to within 0.05 foot of grades indicated on the Drawings, except bring perimeter surface grades along steel edge, paving, curbs, and other structures to within 0.01 foot of grades indicated on the Drawings.
 2. Transition soil surface grades along steel edge, paving, curbs, and other structures to areas of less strict tolerance over a 5-foot distance.
- C. Allowances: Make proper allowances for settlement, spoils from plant pits, and addition of soil amendment.

3.09 ADJUSTING

- A. Amended Soil Finished Grade:
1. Provide allowance for adjustment grading work with accepted equipment capable of smoothing and shaping the curving and sloped surface of the land forms indicated on the Drawings.

2. After the final tilling of the top lift of amended soil and after amended soil surface elevations have been graded to be within the specific tolerance, perform adjustment grading work as directed by the Landscape Architect in the field.
3. Do not rely on adjustment grading to bring finished grade elevation to within the specified tolerance.

3.10 FIELD QUALITY CONTROL

A. Aesthetic Acceptance of Grades:

1. Upon Completion of finish grading Work, schedule with the Landscape Architect a review to obtain aesthetic acceptance.
2. Provide 1 week minimum advance written notification.
3. Do not commence seeding, sodding, or other planting Work until receiving aesthetic acceptance.

END OF SECTION 329119

SECTION 329200 - TURF AND GRASSES

PART 1 – GENERAL

1.01 SUMMARY

A. Section Includes:

1. Hydroseeding.
2. Sodding.
3. Meadow grasses and wildflowers.

B. Related Sections:

1. Section 312219, Planting Area Finish Grading.
2. Section 329113, Planting Soil Preparation.
3. Section 329300, Plant Material.

1.02 REFERENCES

A. AOSA – Association of Official Seed Analysts.

1. Rules for Testing Seeds, Journal of Seed Technology, 1991 Edition.

B. FSA – Federal Seed Act.

C. TPI – Turfgrass Producers International.

1.03 DEFINITIONS

A. Duff Layer: The surface layer of native topsoil that is composed of mostly decayed leaves, twigs, and detritus.

B. Finish Grade: Elevation of finished surface of planting soil.

C. Manufactured Topsoil: Soil produced off-site by homogenously blending mineral soils or sand with stabilized organic soil amendments to produce topsoil or planting soil.

D. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. This includes insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. It also includes substances or mixtures intended for use as a plant regulator, defoliant, or desiccant.

- E. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. These include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.
- F. 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.
- G. PLS: Pure Live Seed.
- H. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or top surface of a fill or backfill before planting soil is placed.
- I. Subsoil: All soil beneath the topsoil layer of the soil profile, and typified by the lack of organic matter and soil organisms.
- J. 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.

1.04 SUBMITTALS

- A. Product Data:
 - 1. Seed.
 - 2. Sod.
 - 3. Wood Pulp Mulch.
 - 4. Pesticide 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, percentage by weight of each species and variety, and percentage of purity, germination, and weed seed. Include the year of production and date of packaging.
 - 1. Certification of each see mixture for turf grass and meadow grasses. Include identification of source and name and telephone number of supplier.
- C. Qualification Data: For qualified landscape Installer.

1.05 QUALITY ASSURANCE

- A. Regulatory Requirements:
 - 1. Meet requirements of applicable laws, codes, and regulations required by authorities having jurisdiction over Work, including the FSA.

2. Provide for inspections and permits required by federal, state, and local authorities in furnishing, transporting, and installing materials.
- B. Installer Qualifications: A qualified landscape Installer whose work has resulted in successful turf and meadow establishment.
1. Professional Membership: Installer shall be a member in good standing of either the Professional Landcare Network or the American Nursery and Landscape Association.
 2. Experience: Five years' experience in turf installation in addition to requirements in Division 01 Section 'Quality Requirements.'
 3. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.
 4. Personnel Certifications: Installer's field supervisor shall have certification in one of the following categories from the Professional Landcare Network:
 - a) Certified Landscape Technician – Exterior, with installation specialty area, designated CLT-Exterior.
 - b) Certified Turfgrass Professional, designated CTP.
 - c) Certified Turfgrass Professional of Cool Season Lawns, designated CTP-CSL.
 5. Maintenance Proximity: Not more than two hours' normal travel time from Installer's place of business to Project site.
 6. Pesticide Applicator: State licensed, commercial.
 7. Preinstallation Conference: Conduct conference at Project Site prior to beginning work.

1.06 PRODUCT DELIVERY, STORAGE, AND HANDLING

- A. Labeling of Seed and Other Packaged Material:
1. Furnish standard product in unopened manufacturer's standard containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws, as applicable.
 2. Seed analysis meeting requirements of the AOSA Rules for Testing Seeds shall be attached to outside as well as inside container showing species, PLS percentage, germination, purity, inert seed, weed seed, other crop seed, name of certified testing agency and date of test.
 3. No seed will be accepted unless test date is within 8 months of planting date.

- B. Storage of Seed and Other Packaged Material:
 - 1. Ship and store with protection from weather or other conditions which would damage or impair the effectiveness of the product.
 - 2. Items which have become wet, moldy, or otherwise damaged in transit or in storage, will be rejected.
- C. Harvest and Delivery of Sod:
 - 1. Harvest sod from the source and deliver to the project site within 24 hours.
 - 2. Deliver only as much sod as can be installed in one day's work.
 - 3. Sod not transplanted within 8 hours of delivery to site will be rejected.
- D. 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, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
 - 3. Accompany each delivery of bulk materials with appropriate certificates.

1.07 SITE CONDITIONS

- A. Environmental Requirements: Protect plant material and seed being stored on site from sun and drying winds.
- B. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed with beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions.
- C. Existing Condition:
 - 1. Prior to commencement of Work, review and clearly mark in field horizontal and vertical locations of existing public underground utilities and structures with respective utility companies.
 - 2. Prior to commencement of work, review and clearly mark in field horizontal and vertical locations of private underground utilities and structures with the Owner.

1.08 WARRANTY

- A. Warranty Period: Warrant that grasses shall be in healthy and in a vigorous, flourishing condition of active growth at the end of the next growing season after the date of Final Acceptance.
- B. Delays: Delays in completion of planting operations which extend the planting into more than one planting season shall extend the Warranty period correspondingly.
- C. Condition of Grasses: Free of dead or dying patches, and areas shall show foliage of normal density, size, and color.
- D. Coverage: Warrant growth and coverage of seeded planting to the effect that a minimum of 95 percent of the area planted shall be covered with specified planting after one growing season with no bare spots greater than 1 square foot.
- E. Replacement: As soon as weather conditions permit, reseed and resod, without cost to Owner, areas of dead plants and areas where plants are not in a vigorous, thriving condition, during and at the end of the Warranty Period.
- F. Requirements for replacements: Apply requirements of this Specification to replacement Work.
- G. Exceptions: Contractor shall not be held responsible for failures due to ordinary wear, neglect by Owner, vandalism, or other causes outside the Contractor's control.

1.09 MAINTENANCE

- A. Landscape Maintenance Period: Refer to Section 320190.

PART 2 – PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS AND SUPPLIERS

- A. Fescue Seed
 - 1. Pennington Seed, Inc., Madison, GA (800-285-7333) / www.penningtonseed.com
 - 2. Approved Equal.
- B. Zoysia Sod
 - 1. Central Sod, www.plantsod.com, 410-827-5000
 - 2. Approved Equal
- C. Wildflower and Native Grass Seed:
 - 1. Ernst Seeds, ernstseed.com, 800-873-3321
 - 2. Approved Equal.

D. Wood Pulp Mulch: locally provided, triple-shredded hardwood mulch.

E. Fertilizer:

1. Gro-Power Inc., Chino, CA (909-393-3744).
2. Approved Equal.

2.02 SUBSTITUTIONS

A. Seed and Sod Substitutions:

1. If proof is submitted that any seed and/or sod specified is not obtainable, a proposal will be considered for use of the nearest equivalent variety with corresponding adjustment of Contract price.
2. Substantiate such proof in writing no later than 30 days after award of Contract.
3. The above provisions do not relieve Contractor of the responsibility for obtaining specified seed and/or sod in advance if special growing conditions or other arrangements must be made in order to supply specific materials.

2.03 MATERIALS

A. Seed:

1. 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.
2. Seed Species: State-Certified 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 seed:
 - a. Fescue (see plan for locations): Rebel II Tall Fescue (*Festuca arundinacea* 'Rebel II')

B. Turfgrass Sod:

1. Turfgrass Sod: Number 1 Quality/Premium, including limitations on thatch, weeds, diseases, nematodes, and insects, complying with "Specifications for Turfgrass Sod Materials" in TPI's "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.
2. Turfgrass Sod 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.
 - a. Fescue (see plan for locations): Rebel II Tall Fescue (*Festuca arundinacea* 'Rebel II')

- b. Zoysia (see plan for locations): Zenith Zoysia from Central Sod.
3. Quality:
- a. Dense, healthy, field-grown on fumigated soil with the grass having been mowed at 1 inch height before lifting from field.
 - b. Dark green in color, relatively free of thatch, and free from diseases and harmful insects.
 - c. Reasonably free of objectionable grassy and broadleaf weeds. Sod will be considered weed-free if no more than 10 such weeds are found per 100 square feet of sod.
 - d. Sod will be rejected if found to contain the following weeds: Bermudagrass, quackgrass, johnsongrass, poison ivy, nimbleweed, thistle, bindweek, bengrass, perennial sorrel, or bromegrass.
- C. Meadow Grasses and Wildflowers:
- 1. Wildflower and native Grass Seed: Fresh, clean, and dry new seed, of mixed species as follows:
 - a. FACW Wetland Meadow Mix by Ernst Seeds. See plan for location
 - b. Virginia Gentleman's Mix by Ernst Seeds. See plan for location
 - c. Approved Equal.
 - 2. Seed Carrier: Inert material, sharp clean sand or perlite, mixed with seed at a ration of not less than two parts seed carrier to one part seed.
- D. Fiber Mulch: Biodegradable, dyed-wood, cellulose-fiber mulch; nontoxic and free of plant-growth or germination inhibitors; with a maximum moisture content of 15 percent and a pH range of 4.5 to 6.5.
- 1. Conwed Fibers 2000 by Conwed Fibers.
 - 2. Approved Equal.
- E. 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 2 to 5 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.
 - 2. Feedstock: Agricultural, food, or industrial residuals; biosolids, yard trimmings; or source-separated or compostable mixed solid waste.
- F. Fertilizer:

1. Gro-Power by Gro-Power Inc.
 2. Approved Equal.
- G. Pegs:
1. 1 inch square by 6 inch long pine, or 6 inch lengths of wood lath.

2.04 PESTICIDES

- A. General: Pesticide, 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 (Selective and non-Selective): Effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the mulch layer
- C. Post-Emergent Herbicide (Selective and Non-Selective): Effective for controlling weed growth that has already germinated.

2.05 HYDRAULIC EQUIPMENT FOR HYDROSEEDING

- A. Mixer: use a commercial type hydro-seeder with a built-in agitation system having an operating capacity sufficient to agitate, suspend, and homogeneously mix slurry.
- B. Distribution Lines: Large enough to prevent stoppage and to provide even distribution of the slurry over the ground.
- C. Pump Capacity: 150 psi at the nozzle.
- D. Slurry Tank: Minimum capacity at 1,000 gallons and mounted on a traveling unit which will place the slurry tank and spray nozzle within sufficient proximity to the areas to be hydroseeded so as to provide uniform distribution without waste.

2.06 MIXES

- A. Hydroseed Turf Slurry Mix:
 1. Content:
 - a. Fertilizer: 1,300 lbs. per acre.
 - b. Mulch: 2,000 lbs. per acre.
 - c. Seed: 12 lbs. per 1,000 square feet.
 2. Mixing:
 - a. Perform slurry preparation at job site.
 - b. Add water to the tank when the engine is at half throttle.
 - c. When the water level has reached the height of the agitator shaft, establish good re-circulation and add seed.

- d. Do not allow seed to remain more than 30 minutes in slurry.
- e. Add the mulch after the seed, and when the tank is at least 1/3 filled with water.
- f. Add the mulch by the time the tank is 2/3 to 3/4 full.
- g. Commence spraying immediately when the tank is full.

PART 3 - EXECUTION

3.01 SCHEDULE

- A. Plant Fescue seed/sod during one of the following periods. Coordinate planting periods with maintenance periods to provide required maintenance from date of Substantial Completion.
 - 1. Spring Planting: April 1 – June 1
 - 2. Fall Planting: August 15 – October 15
- B. Plant Zoysia seed/sod during the following period. Coordinate planting periods with maintenance periods to provide required maintenance from date of Substantial Completion:
 - 1. Spring Planting: May 15 – August 15
 - 2. No Fall Planting window

3.02 EXAMINATION

- A. General: Examine site and verify that conditions are suitable to receive Work and that no defects or errors are present which would cause defective installation of products or cause latent defect in workmanship and function.
- B. Finish Grade and Soil Preparation Verification: Verify fine grading and soil preparation Work is complete.
- C. Surface Drainage: Verify positive surface drainage of lawn areas.
- D. Notification of Unsuitable Conditions: Before proceeding with Work, notify Owner and Landscape Architect in writing of unsuitable conditions.

3.03 PREPARATION

- A. Protection of Existing Conditions:
 - 1. Use every possible precaution to prevent damage to existing conditions to remain such as structures, utilities, plant material, and paved areas on or adjacent to the site of the Work.
 - 2. Provide barricades, fences, or other barriers to protect existing conditions to remain from damage during construction.

3. Do not store materials or equipment, permit burning, or operate or park equipment under the branches of existing plants to remain.
4. Submit written notification, with photographs, of damaged plants and structures to the Owner immediately.

3.04 SODDING

A. Timing:

1. Install sod within 8 hours of delivery to work site.
2. Sod not transplanted within 8 hours of delivery will be rejected.
3. Do not plant dormant sod or if ground is frozen or muddy.

B. Rolling Sod Bed: Roll amended soil with 200-pound water-ballast roller.

C. Moistening Sod Bed: After unevenness in the soil surface has been corrected, lightly moisten the soil immediately prior to laying the sod.

D. Laying the Sod:

1. Lay the first row of sod in a straight line, with subsequent rows parallel to and tightly against each other, with no spaces between strips.
2. Stagger sod strips to offset joints in adjacent courses.
3. Do not stretch or overlap sod.
4. Butt joints tightly to eliminate voids.
5. Use a sharp knife to cut sod to fit angles and curves.

E. Laying Sod on Slopes:

1. For grades exceeding 3:1, start laying sod at bottom of slope.
2. Lay sod sections at right angles to slope and parallel to contours.
3. Stagger sod strips to offset joints in adjacent courses.
4. Do not stretch or overlap sod.
5. Butt joints tightly to eliminate voids.
6. Use a sharp knife to cut sod to fit angles and curves.
7. Anchor sod on slopes exceeding 1:6 with wood pegs 18" on center, but not less than 2 pegs per sod strip, to prevent shifting. Drive pegs flush with sod surface.

- F. Tamping and Rolling Sod:
 - 1. Thoroughly tamp and roll sod with a 200-pound water-ballast roller to make contact with subgrade, eliminate air pockets, and for a smooth surface.
 - 2. Roll each entire section of completed sod.
 - 3. Work sifted soil or fine sand into minor cracks between pieces of sod; remove excess to avoid smothering sod and adjacent grass.
 - 4. Ensure finished sod surface is flush with adjoining grass areas, pavement or top surface of curbs.
- G. Watering: Saturate sod with fine water spray within two hours of planting. During first week after planting, water daily or more frequently as necessary to maintain moist soil to a minimum depth of 1- 1/2 inches below the sod.

3.05 HYDROSEEDING

- A. Application: Mix specified seed, fertilizer, and fiber mulch in water, using equipment specifically designed for hydroseeding application. Continue mixing until uniformly blended into homogeneous slurry suitable for hydraulic application.
 - 1. Mix slurry with tackifier.
 - 2. Apply slurry uniformly to all areas to be seeded in a one-step process. Apply slurry at a rate so that mulch component is deposited at not less than 1500-lb/acre dry weight, and seed component is deposited at not less than the specified seed-sowing rate.
 - 3. Keep hydroseeding within designated areas and keep from contact with other plant material.
- B. Unused Mix:
 - 1. Do not use slurry mixture which has not been applied within 4 hours of mixing.
 - 2. Remove promptly from the site.
- C. Protection: After application, do not operate any equipment over the hydroseeded areas.
- D. Reseeding: Reseed areas and parts of areas which fail to show a uniform stand of grasses until areas are covered with a uniform stand of grass with full coverage.
- E. Clean-Up: Clean overspray from structures, furniture, paving, and other non-planting areas immediately after completion of Work.
- F. Erosion Repair: Repair erosion until grass is established.

3.06 SEEDING AREAS TOO SMALL TO HYDROSEED

- A. Seed Application: Broadcast seed evenly with a mechanical seeder at a rate of 10 pounds per 1,000 square feet.
- B. Broadcast 50 percent of the seed in one direction and broadcast the remaining seed in a direction 90 degrees to the first direction over the same area.
- C. Topdressing: Sprinkle a 1/4-inch depth of amended soil over seeded area immediately after seeding.

3.07 PROTECTION

- A. After application, do not operate any equipment or allow any foot traffic over the lawn areas until lawn is established enough to prevent soil from eroding.
- B. Do not operate any equipment on lawn until ground is firm enough that ruts will not occur.

3.08 SATISFACTORY TURF

- A. Turf installations shall meet the following criteria as determined by the Landscape 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 5 inches by 5 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. Use specified materials to reestablish turf that does not comply with requirements and continue maintenance until turf is satisfactory.

3.10 MEADOW

- 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 a total rate per manufacturer's direction.
- C. Brush seed into top 1/16 inch of soil, roll lightly, and water with fine spray.
- D. Protect seeded areas from hot, dry weather or drying winds by applying compost mulch within 24 hours after completing seeding operations. Soak areas, scatter mulch uniformly to a thickness of 3/16 inch, and roll surface smooth.
- E. Water newly planted areas and keep moist until meadow is established.

3.11 PESTICIDE APPLICATION

- A. Apply pesticides and other chemical products and biological control agents in accordance with requirements of authorities having jurisdiction and manufactures' written recommendations. Coordinate applications with Owner's operations and others in proximity to the Work. Notify Owner before each application is performed.
- B. Post-Emergent Herbicides (Selective and Non-Selective): Apply only as necessary to treat already-germinated weeds in accordance with manufacturer's written recommendations.

3.12 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 temporary fencing or barricades and warning signs as required to protect newly planted areas from traffic. Maintain fencing an barricades throughout initial maintenance period and remove after plantings are established.
- C. Remove nondegradable erosion-control measures after grass establishment period.

3.13 FIELD QUALITY CONTROL

- A. Field Observation Reviews by Landscape Architect: Coordinate and schedule with Landscape Architect.

END OF SECTION 329200

SECTION 329300 - PLANT MATERIAL

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Trees.
2. Shrubs.
3. Perennials.
4. Ground Cover.
5. Wood Chip Mulch.
6. Tree Stabilization.
7. Related Materials.

B. Related Sections:

1. Section 329113, Planting Soil Preparation.
2. Section 329119, Planting Area Finish Grading.
3. Section 329200, Turf and Grasses.

1.03 REFERENCES

- A. ANSI – American National Standards Institute: Z60.1-1996 – American Standard for Nursery Stock.
- B. ICBN – International Code of Botanical Nomenclature.
- C. ICNCP – International Code of Nomenclature of Cultivated Plants.
- D. NAAPS – National Arborist Association: Pruning Standards for Shade Trees, 1988

1.04 DEFINITIONS

COLONIAL HEIGHTS HIGH SCHOOL RENOVATION/ADDITION
COLONIAL HEIGHTS, VIRGINIA
Architect's Project No: 611565

- A. Antidesiccant: Water-insoluble emulsion permeable moisture retarder, film forming, for trees and shrubs. Deliver in original, sealed, and fully labeled containers and mix according to manufacturer's written instructions.
- B. Backfill: The earth used to replace or the act of replacing earth in an excavation.
- C. Balled and Burlapped Stock: Plants dug with firm, natural balls of earth in which they were grown, with ball size not less than the diameter and depth recommended by ANSI Z60.1 for the type and size of plant required; wrapped with burlap, tied, rigidly supported, and drum laced with twine with the root flare visible at the surface of the ball as recommended by ANSI Z60.1.
- D. Bare-Root Stock: Plants with a well-branched, fibrous-root system developed by transplanting or root pruning, with soil or growing medium removed, and with not less than the minimum root spread according to ANSI Z60.1 for the type and size of the plant required.
- E. Burlap: Non-synthetic, biodegradable.
- F. Caliper: Trunk diameter measured at a point 6 inches above the ground line if the resulting measurement is not more than 4-inches. If the resulting measurement is 4-inches or more, the measurement is made at a point 12 inches above the ground.
- G. Container-Grown Stock: Healthy, vigorous, well-rooted plants grown in a container, with a well-established root system reaching the sides of the container and maintaining a firm ball when removed from the 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 the type and size of the plant required.
- H. Finish Grade: Elevation of finished surface of planting soil.
- I. Manufactured Topsoil: Soil produced off-site by homogeneously blending mineral soils or sand with stabilized organic soil amendments to produce topsoil or planting soil.
- J. Pests: Living organisms that exist where they are not desired, or that cause damage to plants, animals, or people. These include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.
- K. Plant Height: Measurement of main body height, not measurements to top branch tip.
- L. Plant Spread: Measurement of main body diameter, not measurement from branch tip to branch tip.
- M. Planting Area: Areas to be planted.
- N. Plant; Plants; Plant Material: These terms refer to vegetation in general, including trees, shrubs, vines, ground covers, ornamental grasses, bulbs, corms, tubers, or herbaceous vegetation.

- O. 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.
- P. Stem Girdling Roots: Roots that encircle the stems (trunks) of trees below the soil surface.
- Q. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.
- R. Subsoil: All soil beneath the topsoil layer of the soil profile and typified by the lack of organic matter and soil organisms.
- S. 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.

1.05 SUBMITTALS

- A. Product Data:
 - 1. Anti-Desiccant Spray.
 - 2. Mycorrhizal inoculant.
 - 3. Pesticides and Herbicides.
 - 4. Steel Edge and Stakes.
 - 5. Tree Ties.
- B. Samples:
 - 1. Wood Mulch – ½-pound bag.
 - 2. Edging Materials and Accessories.
 - 3. Tree Tie – 1 tie.
 - 4. Tree Stake – 1 piece, 12-inches long, of each size.
- C. Plant Material Location Data:
 - 1. Quantities and sizes, in writing, of each plant material type at each nursery or other place of growth.
 - 2. Address, phone number, and contact person for each nursery or other place of growth.
- D. Plant Material Photographs:

1. At least 14 days prior to submittal of Plant Material Location Data, submit three color photographs in digital format of each required species and size of plant material as it will be furnished to the Project.
2. Take photographs from an angle depicting true size and condition of the typical plant to be furnished.
3. Include a scale rod or other measuring device in each photograph.
4. For species where more than 20 plants are required, include a minimum of three photographs showing the average plant, the best quality plant, and the worst quality plant to be furnished.
5. Identify each photograph with the full scientific name of the plant, plant size, and name of the growing nursery.

E. Maintenance Instructions:

1. Recommended procedures to be established and documented for the Owner for maintenance of plants during a calendar year. Submit before start of required maintenance periods.

1.06 QUALITY ASSURANCE

A. Regulatory Requirements:

1. Meet requirements of applicable laws, codes, and regulations required by authorities having jurisdiction over Work.
2. Provide for inspections and permits required by federal, state, and local authorities in furnishing, transporting, and installing materials.

B. Contractor Qualifications:

1. The work of this section shall be performed by a single company specializing in landscape installation, and shall be performed by skilled work people thoroughly experienced in the necessary crafts.

C. Plant Material:

1. Provide quality, size, genus, species, and variety of plants indicated, complying with applicable requirements in ANSI Z60.1.

D. Measurements:

1. Trees and Shrubs: Measure with branches and trunks or canes in their normal position. Take height measurements from or near the top of the root flare for field-grown stock and container grown stock. Measure main body of tree or shrub for height and spread; do not measure branches or roots tip to tip. Take caliper measurements 6 inches above the root flare for trees up to 4-inch caliper size, and 12 inches above the root flare for larger sizes.

2. Other Plants: Measure with stems, petioles, and foliage in their normal position.
- E. Tree Staking Mock-Up:
1. Prepare mock-up of tree staking system.
 2. Construct mock-up using specified materials.
 3. Accepted mock-up shall be project standard by which Work will be judged.
- F. Pre-Installation Conference:
1. Conduct conference at Project Site.

1.07 PRODUCT DELIVERY, STORAGE, AND HANDLING

- A. Packaged Materials:
1. 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, utilities, walkways and pavements, or on existing turf areas or plants.
 2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge or soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
 3. Accompany each delivery truck of bulk materials with appropriate certificates
- C. Delivering Plants:
1. Do not prune trees and shrubs before delivery.
 2. Deliver plants after preparations for planting have been completed, and install immediately. If planting is delayed more than 6 hours after delivery, set plants and trees in their appropriate aspect (sun, filtered sun, or shade), protect from weather and mechanical damage, and keep roots moist.
- D. Handling Plants:
1. Handle plant stock by root ball or container.
 2. Do not lift or handle container plants by tops, stems, or trunks.
 3. Do not bend or bind/tie trees or shrubs in such a manner as to destroy their natural shape.

4. Protect bark, branches, and root systems from sun scald, drying, wind burn, sweating, whipping, and other handling and tying damage. Provide protective covering during shipping and delivery.
 5. Pad trunk and branches at all points of contact between plant material and equipment.
 6. Do not drop plants during delivery and handling.
- E. Anti-Desiccant:
1. Spray plant material in full leaf with anti-desiccant immediately before transporting.
 2. Meet requirements of anti-desiccant manufacturer's current printed application instructions.
- F. Digging Plants:
1. Dig ball and burlap plants with firm, natural balls of earth of diameter meeting or exceeding requirements of ANSI Z60.1 and of sufficient depth as required to include the fibrous and feeding roots.
- G. Plant Storage Prior to Installation:
1. Protect plant root balls from sun and drying winds.
 2. Keep root balls moist.
 3. Keep sun-sensitive plants shaded.
 4. Anchor plants to prevent damage from strong winds.
 5. Do not remove container grown stock from containers until time of planting.

1.08 SITE CONDITIONS

- A. Environmental Requirements: Protect plant material being stored on site from sun and drying winds.
- B. Existing Conditions:
1. Prior to commencement of Work, review and clearly mark in field horizontal and vertical locations of public existing underground utilities and structures with respective utility companies
 2. Prior to commencement of work, review and clearly mark in field horizontal and vertical locations of private underground utilities and structures with the Owner.

1.09 WARRANTY PLANT MATERIAL

- A. Warranty Period: Warrant that plant material will be healthy and in vigorous, flourishing condition of active growth one year from date of Final Completion.
- B. Delays: Delays in completion of planting operations which extend the planting into more than one planting season shall extend the Warranty Period correspondingly.
- C. Condition of Plants: Plants shall be free of dead or dying branches and branch tips, with foliage of a normal density, size, and color.
- D. Incorrect Materials
 - 1. During Warranty Period, replace at no cost to the Owner, plants revealed as being untrue to name.
 - 2. Provide replacements of a size and quality to match the planted materials at the time the mistake is discovered.
- E. Replacements:
 - 1. As soon as weather and seasonal conditions permit, replace, without cost to the Owner, dead plants and plants not in a vigorous, thriving condition, as determined by the Landscape Architect during and at the end of the Warranty Period.
 - 2. Apply requirements of this section to replacements.

1.10 MAINTENANCE

- A. Maintenance Service: Refer to Section 320190.

PART 2 – PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS AND SUPPLIERS

- A. Anti-Desiccant Spray:
 - 1. Aquatrols, Paulsboro, NJ (856-537-6003) / www.aquatrols.com
 - 2. Approved equal.
- B. Mycorrhizal inoculant:
 - 1. Plant Health Care, Inc., Pittsburgh, PA (800-421-9051) / www.planthealthcare.com.
 - 2. Approved Equal.
- C. Steel Edge and Stakes:

1. The J.D. Russell Company, Tucson, AZ (800-888-7425) /
www.jdrusselcom.com.
2. Approved equal.

D. Tree Ties:

1. DeepRoot, San Francisco, CA (800-458-7668) / www.deeproot.com
2. Approved Equal.

2.02 SUBSTITUTIONS

- A. Plant Material: Accepted substitute plants shall be true to species and variety and shall meet requirements of this Section except that plants larger than specified may be used, if accepted by the Landscape Architect, and if without additional cost to the Owner.

2.03 MATERIALS

A. Plant General Requirements:

1. General: Furnish nursery-grown plants true to genus, species, variety, cultivar, stem form, shearing, and other features indicated in Plant Schedule shown on Drawings.
2. Growing Practices: Nursery grown in accordance with best horticultural industry practices and complying with recommendations and requirements of ANSI Z60.1.
3. Collected Stock: Do not use plants harvested from the wild, from native stands, from an established landscape planting, or not grown in a nursery unless otherwise indicated.
4. Nomenclature: Plant nomenclature shall meet requirements of ICBN and ICNCP.
5. Climatic Growing Conditions: Plant material shall be grown under climatic conditions similar to those of the project for at least two years unless otherwise accepted by the Landscape Architect.
6. Container Growth Limitations: Container stock, excluding annuals, shall have been grown in the containers in which plant material is delivered for at least six months, but not more than two years.
7. Root Ball or Container Sizes: Meet or exceed requirements of ANSI Z60.1.
8. Branching: Structurally strong and able to stand upright without stakes or guys on a windless day; exceptionally heavy, symmetrical, tightly knit, so trained or favored in development and appearance as to be superior in form, number of branches, compactness and symmetry.

9. Vigor: Sound, healthy, and vigorous, well branched and densely foliated when in leaf.
 10. Disease and Pests: Free of disease, insect pests, eggs, or larvae.
 11. Root System: Healthy well-developed root systems, free of kinked, circling, girdling and center roots, root-bound conditions, and cracked or broken root balls.
 12. Plant Size: Provide plants of sizes and grades complying with ANSI Z60.1 for types and form of plants required. Plants of a larger size may be used if acceptable to the Landscape Architect, with a proportional increase in the size of the root balls.
 13. Pruning: Do not prune, thin, or shape plants before delivery without approval by the Landscape Architect.
 14. Unacceptable Conditions: Multiple leaders, unless specified; damaged or crooked leaders; bark abrasions; sunscald; disfiguring knots; or fresh cuts of limbs over $\frac{3}{4}$ -inch diameter which have not completely callused.
 15. If formal arrangements or consecutive order of plants is shown on Drawings, select stock for uniform height and spread, and number the plant labels to assure symmetry in planting.
 16. Annuals and Biennials: Provide healthy, disease-free plants of species and variety shown or listed, with well-established root systems reaching to sides of the container to maintain a firm ball, but not with excessive root growth encircling the container. Provide only plants that are acclimated to outdoor conditions for delivery and that are in bud but not yet in bloom.
- B. Anti-Desiccant Spray:
1. Leafshield Anti-Transpirant by Aquatrols.
 2. Approved Equal.
- C. Mycorrhizal Inoculant:
1. Mycor Tree Saver Transplant by Plant Health Care, Inc.
 2. Approved Equal.
- D. Water: Clean, potable and free of toxic elements.
- E. Wood Mulch: Organic mulch free of soil, rocks, toxic material, and other debris, and suitable for top dressing of trees, shrubs, and plants. Mulch shall be of a uniform grade with no additives or any other treatment. The pH factor shall range from 5.8 to 6.2.
1. Mini Pine Bark Nuggets: $\frac{1}{2}$ " maximum length; natural color.

- F. Anti-Desiccant: Commercially available spray protective coating, designed to reduce plant transpiration loss, which produces a moisture retarding barrier not removable by rain or snow.
- G. Steel Edge: Flexible carbon steel, ¼-inch thick, 5-inches high by 16 feet length (actual coverage 15'-4"); black factory powder coat paint finish electrostatically applied and oven baked; double-staked overlap joints; and designed to receive tapered steel stakes.
 - 1. Duraedge by The J.D. Russell Company.
 - 2. Approved Equal.
- H. Steel Stakes: Steel, tapered, 16-inch minimum length, and finished to match specified steel edging, designed specifically to anchor steel edge in place, manufactured by manufacturer of the steel edge for which they will be used.
 - 1. Duraedge by The J.D. Russell Company .
 - 2. Approved Equal.
- I. Steel Edge Accessories: Standard start/end sections, 90 degree corners, and splicers finished to match specified steel edging, as required.
 - 1. Duraedge by The J.D. Russell Company.
 - 2. Approved Equal.
- J. Tree Stakes: White cedar with bark attached and showing no sign of cracking or decay, with a maximum allowable deflection of ten percent (10%). See Specifications for stake size relative to tree size.
- K. Tree Ties: Flat woven polypropylene material, ¾-inch wide, 900 lb break strength, lock stitch with rounded weave.
 - 1. Arbortie Green by DeepRoot .
 - 2. Approved Equal.
- L. Bolts, Lock Washers, and Nuts: Galvanized steel.

2.04 MIXES

- A. Planting Pit Backfill Mix: Refer to Section 329113

2.05 SOURCE QUALITY CONTROL

- A. Plant Material Review and Tagging:

1. Trees will be reviewed, photographed, and tagged using irremovable tags by the Landscape Architect at the nursery, or other place of growth, prior to delivery of trees to the site.
2. At the Landscape Architect's discretion, shrubs may or may not be reviewed, photographed, and tagged by the Landscape Architect at the nursery or other place of growth.
3. Tagging of plant material at the nursery or place of growth does not cancel the right of the Landscape Architect to reject plant material at the site if damage or unacceptable conditions are found that were not detected at the nursery, place of growth, or in the submitted photographs.

PART 3 – EXECUTION

3.01 SCHEDULE:

- A. Plant during one of the following periods. Coordinate planting periods with maintenance periods to provide required maintenance from date of Substantial Completion.
 1. Spring Planting: March 1 – May 1
 2. Fall Planting: September 15 – November 15

3.02 EXAMINATION

- A. General: Examine site and verify that conditions are suitable to receive Work and that no defects or errors are present which would cause defective installation of products or cause latent defects in workmanship and function.
- B. Fine Grading and Soil Preparation: Verify that fine grading and soil preparation Work is complete.
- C. Surface Drainage: Verify positive surface drainage of planted areas.
- D. Notification: Before proceeding with Work, notify the Owner in writing of unsuitable conditions.

3.03 PREPARATION

- A. Protection of Existing Conditions:
 1. Use every possible precaution to prevent damage to existing conditions to remain such as structures, utilities, plant material, and paved areas on or adjacent to the site of the Work.
 2. Provide barricades, fences, or other barriers to protect existing conditions to remain from damage during construction.

3. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.
4. Do not store materials or equipment, permit burning, or operate or park equipment under the branches of exiting plants to remain.
5. Submit written notification of damaged plants and structures to the owner immediately.

3.04 SUBSURFACE OBSTRUCTIONS

A. Plant Pit Excavation:

1. If rock, underground utilities, structures, tree roots or other obstructions are encountered in the excavation of plant pits, alternate locations may be accepted by the Landscape Architect.
2. Submit written notification of encountered obstruction to the Landscape Architect immediately.
3. Irrigation Piping: Reroute around the plant root ball.

3.05 STEEL EDGE

A. Locations: Install where indicated on Drawings.

B. Horizontal Alignment:

1. Install straight sections true to the alignments as indicated in the drawings, free of waves or bends, using string lines as guides.
2. Install curved sections true to the alignments as indicated in the drawings, free of waves or bends, following marked alignments approved in the field by the Landscape Architect.
3. The Landscape Architect shall review all layouts prior to final installation.
4. Field weld all butt joints and at joints that change in orientation greater than 45 degrees.

C. Vertical Alignment:

1. Install parallel with finished grade.
2. Kerf bottom of header at 12-inches on center to within 1-inch of top to bend header at sharp vertical curves.
3. Do not kerf closer than 12-inches to stake.

4. Looser kerf spacing may be accepted by the Landscape Architect at larger radius vertical curves.
 5. Submit proposed kerf spacing to Landscape Architect for acceptance.
- D. Accessories: Install per manufacturer's instructions.
- E. Stakes:
1. Install stakes in solid undisturbed soil.
 2. Recompact loose soil to at least 85 percent relative compaction before installing stakes.
 3. Install stakes at every location in steel edging designed to receive stakes.
 4. Drive all stakes below top elevation of edging.
- F. Damaged Edging: replace edging sections damaged by construction operations.

3.06 PLANT LAYOUT

- A. Trees:
1. Stake location of trees where indicated on Drawings.
 2. Scale tree locations where no dimensions are given.
 3. Drive a 3-foot long wood lath stake at each tree location and mark each tree type with different color survey tape.
 4. Contact the Landscape Architect to review tree locations in field prior to excavating plant pits and installing irrigation.
 5. Do not excavate plant pits or install irrigation until the Landscape Architect has accepted the locations.
- B. Shrubs:
1. Do not remove container-grown shrubs from containers until time of planting.
 2. Layout container-grown and B&B shrubs as indicated on the Drawings.
 3. Scale shrub locations where no dimensions are given.
 4. Contact the Landscape Architect to review shrub locations in field prior to excavating plant pits and installing irrigation.
 5. Do not excavate plant pits or install irrigation until the Landscape Architect has accepted the locations.

C. Perennials:

1. Do not remove container-grown perennials from containers until time of planting.
2. Layout perennials in their containers as indicated on the Drawings.
3. Scale perennial locations where no dimensions are given
4. Contact the Landscape Architect to review perennial locations in field prior to excavating plant pits and installing irrigation.
5. Do not excavate plant pits or install irrigation until the Landscape Architect has accepted the locations.

D. Ground Cover:

1. Layout sample spacing of ground cover for review and approval of Landscape Architect.
2. Do not excavate plant pits or install irrigation until the Landscape Architect has accepted the locations.

3.07 EXCAVATION OF TREE AND SHRUB PLANT PITS

A. Equipment:

1. Excavate pits with a back-hoe or hand digging.
2. Do not use an auger.

B. Dimensions:

1. Excavate plant pits to a diameter which is 3 times the root ball diameter, except where indicated otherwise on the Drawings
2. Excavate plant pits to a depth equal to the root ball height. Trim perimeter of bottom of pit leaving center area of bottom raised slightly to support root ball and assist in drainage away from center. Do not further disturb base. Ensure that root ball will sit on undisturbed base soil to prevent settling.
3. Do not excavate deeper than depth of the root ball, measured from the root flare to the bottom of the root ball.
4. If area under the plant was initially dug too deep, add soil to raise it to the correct level and thoroughly tamp the added soil to prevent settling.
5. Center plant pits on plant locations where possible.
6. Where plant pits cannot be excavated to specified dimension nor centered on plant locations due to obstructions such as paving, walls, curb, or other

structures, excavate pits in directions without obstruction until pit volume equals the specified plant pit volume, except where indicated otherwise.

7. Do not undercut adjacent obstruction unless accepted by the Owner.
8. Excavate plant pit sides along adjacent elements such as paving, walls, curbs, and other structures at a 45 degree angle sloping away from the bottom surfaces of the adjacent elements, except where indicated otherwise.

C. Obstructions:

1. Notify Landscape Architect if unexpected rock or obstructions detrimental to trees or shrubs are encountered in excavations.

a) Hardpan Layer: Drill 6-inch diameter holes, 36 inches apart, into free-draining strata or to a depth of 10 feet, whichever is less, and backfill with free-draining material.

D. Drainage:

1. Notify the Landscape Architect if subsoil conditions evidence unexpected water seepage or retention in tree or shrub planting pits.

3.08 PLANTING AND BACKFILL OPERATIONS – TREES, SHRUBS, AND VINES

A. Protection of Plants Prior to Installation:

1. Protect plant root balls from sun or drying winds.
2. Keep root balls of plants that cannot be planted immediately upon delivery in the shade, well-protected and well-watered.

B. Locating Root Flare

1. Before planting, verify that root flare is visible at top of the root ball according to ANSI Z60.1. If root flare is not visible, remove soil in a level manner from the root ball to where the top-most root emerges from the trunk. After soil removal to expose the flare, verify that the root ball still meets size requirements.

C. Removal of Containers and Boxes:

1. Remove container stock carefully after container or box has been cut on two sides with accepted cutter.
2. Do not use spade to cut containers.

D. Plant Placement:

1. Handling plant carefully, set plant root ball on bottom of pit and center on accepted horizontal location.

2. Install plant root ball vertically with the root flare 2-inches above the adjacent finished grade.
 3. When planting on slopes, set the plant so that the root flare on the uphill side is flush with the surrounding soil on the slope; the edge of the root ball on the downhill side will be above the surrounding soil. Apply enough soil to cover the downhill side of the root ball.
- E. Removal of Root Ball Wrapping Materials:
1. Completely remove all inorganic, plastic, or synthetic strings, ropes, twine, wire lacing, treated burlap, and wire baskets. Remove from planting pit.
 2. If the complete removal of untreated burlap from a large-size caliper tree would severely disturb the root ball, the burlap should be pulled down so it is below the upper third of the root ball. No burlap shall emerge from the soil or be near the soil surface after the hole is backfilled.
- F. Root Ball Scarification:
1. After removing plant from container, scarify side of root ball to prevent root-bound conditions.
 2. Loosen root ball soil surface to a depth of 1/8 to 1/4-inch without damaging roots or breaking root ball.
- G. Cutting Circling Roots:
1. If circling roots are encountered at root ball sides, notify the Landscape Architect for field review.
 2. Upon Landscape Architect's acceptance, cut roots on 4 sides of root ball 90 degrees apart and 2-inches into the root ball.
 3. Use a 4-inch wide sharp straight blade.
 4. Keep spade or knife sharp to cut roots cleanly.
- H. Backfill Mix Placement:
1. Place mix carefully so as not to damage the plants root ball, trunk, branches, or foliage.
 2. Fill pit until top of backfill mix is even with top of the root ball.
- I. Soil Saucer:
1. Using prepared Backfill Mix, create a 6-inch high, firmly formed soil saucer at the perimeter of the root ball to facilitate watering. Angle of repose varies with steepness of slope and soil type – see Drawings.

- J. Mycorrhizal Inoculant:
 - 1. Application rates shall be as indicted in manufacturer's written instructions.
 - 2. Thoroughly mix mycorrhizal inoculant into the upper 6 to 8-inches of the backfill mix next to the root ball.
- K. Backfill Mix Settlement:
 - 1. After backfill mix has been placed settle mix by watering evenly.
 - 2. Fill settled backfill mix areas with additional backfill mix as required to bring it even with the top of the root ball.
 - 3. Continue filling settled areas and drenching with water until settlement stops.
- L. Settled Plant Adjustment: Raise plant root balls which settle so that root flares are at the specified elevation relative to the adjacent finished grade.
- M. Watering: Thoroughly water each plant immediately following planting by soaking without runoff.

3.09 TREE, SHRUB, AND VINE PRUNING

- A. Remove only dead, dying, or broken branches. Do not prune for shape.
- B. Prune, thin, and shape trees, shrubs, and vines as directed by the Landscape Architect.
- C. Prune, thin, and shape trees, shrubs, and vines according to standard professional horticultural and arboricultural practices. Unless otherwise indicated by Architect, do not cut tree leaders; remove only injured, dying, or dead branches from trees and shrubs, and prune to retain natural character.
- D. Do not apply pruning paint to wounds.

3.10 TREE STAKING SYSTEM

- A. All newly planted and relocated trees on the site, with exception of those employing the Root Ball Anchor system (see Drawings), are to be staked.
- B. All staking shall be done during the planting operation.
- C. Stake Size:
 - 1. For trees smaller than or equal to 3 ½-inch caliper, install 8-foot long stakes that are not less than 2-inches nor more than 2 ¾-inches in diameter.
 - 2. For trees 3 ½-inch caliper or greater, install 10-foot long stakes that are not less than 3-inches in diameter nor more then 3 ¾-inches in diameter.

D. Orientation and Quantity:

1. Deciduous Trees: Locate two stakes in a line with trunk of tree perpendicular to the prevailing wind direction. Stakes shall be placed a minimum distance of 12-inches outside the root ball, taking care to not penetrate the root ball.
2. Evergreen Trees: Locate one stake on side of prevailing wind. Stake shall be placed a minimum distance of 18-inches away from the trunk of the tree, taking care to not penetrate the root ball. For sites with swirling winds, use three stakes and install as per specifications for multi-stemmed trees.
3. Multi-Stemmed Trees: Locate three stakes at 120-degrees around the main trunk. Stakes shall be placed a minimum distance of 12-inches outside the root ball, taking care to not penetrate the root ball.
4. Deciduous and Evergreen Trees on a Slope: Locate three stakes at 120-degrees around the trunk of the tree. Stakes on the uphill side of the tree shall be placed a minimum distance of 12-inches outside the root ball, taking care to not penetrate the root ball. Stakes on the downhill side of the tree shall be placed outside the planting pit.
5. Large Shrubs: Locate two stakes in a line with the primary trunk of the shrub perpendicular to the prevailing wind direction. Stakes shall be placed a minimum distance of 12-inches outside the root ball, taking care to not penetrate the root ball.

E. Stake Depth:

1. Drive 8-foot long stakes into soil to a minimum of 12-inches below the root ball bottom.
2. Drive 10-foot long stakes into soil to a minimum of 18-inches below the root ball bottom.
3. Pre-drill pilot holes $\frac{1}{2}$ diameter of the stake if required to drive stakes in hard soil conditions.

F. Tying Trees to Tree Stakes:

1. Fasten tree to each stake with a suitable length of $\frac{3}{4}$ -inch wide polypropylene tie. Knot or nail the tie to the stake with 1-inch galvanized roofing nails to prevent slippage.
2. Refer to detail on Drawings.

G. Removal of Tree Stakes and Ties:

1. The contractor shall be responsible for removing staking and guying materials no later than one year after planting.

2. Fill any holes left by the stake with soil of the same quality as Backfill used at time of planting.

3.11 PLANTING AND BACKFILL OPERATIONS – PERENNIALS AND GROUND COVER

A. Protection of Plants Prior to Installation

1. Protect plants from sun and drying winds.
2. Keep plants that cannot be planted immediately upon delivery in the shade, well-protected and well-watered.

B. Removal of Containers:

1. Remove container stock carefully after containers have been cut on two sides with accepted cutter.
2. Do not use spade to cut containers.

C. Root Ball Scarification:

1. After removing plant from container, scarify side of root ball to prevent root-bound conditions.
2. Loosen root ball soil surface without damaging roots or breaking root ball.

D. Cutting Circling Roots:

1. If circling roots are encountered at root ball sides, cut roots on 4 sides of root ball 90 degrees apart and $\frac{3}{4}$ -inch into the root ball.
2. Use a 4-inch wide sharp, straight blade.
3. Keep knife sharp to cut roots cleanly.

E. Plant Placement:

1. Handling plant carefully, set plant root ball on bottom of pit and center on accepted horizontal location.
2. For Perennials, install plant root ball flush with the adjacent finished grade after settlement except where indicated otherwise.
3. For Ground Cover, install plant root ball flush with the adjacent finished grade after settlement except where indicated otherwise.

F. Backfill Mix Placement:

1. Place mix carefully so as not to damage the plants root ball, stem, branches, or foliage.

2. Fill pit until top of backfill mix is even with the adjacent finished grade.

G. Settled Plant Adjustment: Raise plant root balls which settle so that tops of root balls are at the specified elevation relative to the adjacent finished grade.

H. Watering: Water thoroughly immediately after planting, taking care to not cover crowns of plants with soil.

3.12 WOOD CHIP MULCH INSTALLATION

A. Depth:

1. Install a 2-inch depth mulch layer over tree watering basins and shrub areas unless indicated otherwise.

2. Install a 1-inch depth mulch layer over perennials areas, unless indicated otherwise.

3. Install a 1-inch depth mulch over ground cover areas, unless indicated otherwise.

B. Surface: Rake mulch surface smooth.

C. Woody Plant Stems: Slope mulch away from woody plant stems so that mulch does not touch stems. Maintain 2-inch space between root collar and mulch.

3.13 CLEANUP AND PROTECTION

A. During planting, keep adjacent paving and construction clean, and work area in an orderly condition.

B. Protect plants from damage due to landscape operations and operations of other contractors and trades. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged plantings.

C. After installation and before Substantial Completion, remove nursery tags, nursery stakes, tie tape, labels, wire, burlap, and other debris from planter material, planting areas, and Project site.

3.14 DISPOSAL

A. Separate recyclable materials produced during this work from other non-recyclable materials. Store or stockpile without intermixing with other materials and transport them to recycling facilities.

B. Remove surplus soil and waste material including excess subsoil, unsuitable soil, trash, and debris and legally dispose of them off Owner's property.

3.15 FIELD QUALITY CONTROL

- A. Field Observation Review by Landscape Architect: Coordinate and schedule with the Landscape Architect.

END OF SECTION 329300

SECTION 331200 - WATER UTILITY DISTRIBUTION EQUIPMENT

PART 1 - GENERAL

1.1 RELATED SECTIONS

- A. Section 312316: Excavation.
- B. Section 312333: Trenching and Backfilling.

1.2 QUALITY ASSURANCE

- A. Product Options: Drawings indicate size, profiles, and dimensional requirements of piping and specialties and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."
- B. Regulatory Requirements
 - 1. Comply with requirements of City of Colonial Heights Department of Utilities. Include tapping of water mains and backflow prevention.
- C. Piping materials shall bear label, stamp, or other markings of specified testing agency.
- D. Comply with ASTM F 645 for selection, design, and installation of thermoplastic water piping.
- E. Comply with FM's "Approval Guide" or UL's "Fire Protection Equipment Directory" for fire-service-main products.
- F. NFPA Compliance: Comply with NFPA 24 for materials, installations, tests, flushing, and valve and hydrant supervision for fire-service-main piping for fire suppression.
- G. NSF Compliance:
 - 1. Comply with NSF 14 for plastic potable-water-service piping.
 - 2. Comply with NSF 61 for materials for water-service piping and specialties for domestic water.

1.3 REGULATORY REQUIREMENTS

- A. Conform to City of Colonial Heights Department of Utility specifications for materials and installation of the Work of this Section.

1.4 PROJECT RECORD DOCUMENTS

- A. Submit documents under provisions of Section 017000.
- B. Accurately record location of pipe runs, connections, and invert elevations.

PART 2 - PRODUCTS

2.01 WATER DISTRIBUTION PIPE

- A. Ductile Iron Pipe: Asphalt coated, cement lined ductile iron, Class 52 or higher with flexible restrained joints; required for waterline pipes larger than 8".
 - 1. All fittings and hardware shall be epoxy coated.
 - 2. Mechanical joints and jointing materials shall meet requirements of AWWA C111.
 - 3. Locked type mechanical joints may be used where restrained joints are required.
 - 4. Cement mortar lining shall be standard thickness meeting requirements for AWWA C104.

- B. Polyvinylchloride (PVC) pipe shall meet the requirements of AWWA C900, Table 2 (Cast Iron OD) Class 150 except that all connections shall be made using elastomeric gasket joints. No PVC pipe larger than 8" shall be used for water lines.

- C. Underground branch lines 2" and smaller can be type K hard drawn and annealed meeting the requirements of ASTM B88.
 - 1. Copper Fittings shall meet requirements of ANSI B16.22 for wrought copper, compression fitting or pack joint.

2.02 FREESTANDING FIRE HYDRANTS

- A. All Hydrants shall meet City of Colonial Heights Utility Standards.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Verify that excavation base is ready to receive work and excavations, dimensions, and elevations are as indicated on drawings.
- B. Beginning of installation means acceptance of existing conditions.

3.02 PREPARATION

- A. Hand trim excavations to required elevations. Correct over excavation with fill material of coarse aggregate.
- B. Remove large stones or other hard matter which could damage drainage tile or impede consistent backfilling or compaction.

3.03 INSTALLATION

- A. Install pipe, fittings, and accessories in accordance with AASHTO Section 30 and manufacturer's instructions. Seal joints watertight.
- B. Domestic water piping shall have a minimum 3.5' cover.
- C. Place pipe on minimum 4 inch deep bed of VDOT #10 stone dust or sand bed.

- D. Lay pipe to slope gradients noted on layout drawings, with maximum variation from true slope of 1/8 inch in 10 feet.
- E. All domestic water lines shall be pressure tested at 200 psig for two hours; domestic water lines shall be bacteria tested and disinfected to meet the requirements of Virginia Plumbing Code Section 610, the Virginia Department of Health Regulations 12VAC5-590-1210, AWWA C651/C652 and as directed below:
 - a. Flush lines until no dirty water appears at outlet.
 - b. Introduce water to the line being tested at a constant flow rate.
 - c. Fill system or part thereof with water/chlorine solution containing not less than 50 parts per million (60 mg/L) of chlorine. Valve off system or portion being tested and allow to stand for 24 hours; alternatively, allow to stand for 3 hours with 300 parts per million (200 mg/L) chlorine solution. Following testing time, residual chlorine concentration shall be at least 10 mg/L. Chlorine concentrations listed are per VPC 610, which are higher than required by VDH.
 - d. Flush system following time above with clean, potable water until the chlorine is purged from the system.
 - e. After flushing, test in accordance with 12VAC5-590-800 C; samples shall be collected at regular intervals not exceeding 2,000 ft, min.
 - i. Per 12VAC5-590-800, two water samples for bacteriological analysis must be collected at least 24 hours apart and analyzed by a certified laboratory. The results of the samples must indicate no coliform contamination.
 - f. Repeat disinfection if samples show contamination in the system.
- F. Install coarse filter aggregate at sides and over top of pipe.
- G. Backfill in trenches located within paved streets and roads shall be VDOT 21A stone from top of pipe to bottom of pavement.
- H. Utility marker per detail provided.

3.04 FIELD QUALITY CONTROL

- A. Field inspection will be performed under provisions of Section 0143/4500.

3.05 PROTECTION

- A. Protect finished installation.
- B. Protect pipe and filter aggregate cover from damage or displacement until backfilling.

END OF SECTION 331200

SECTION 333000 - SANITARY SEWERAGE UTILITIES

PART 1 - GENERAL

1.01 PERFORMANCE REQUIREMENTS

- A. Gravity flow, Non pressure, Drainage-piping Pressure Rating: 10-foot head of water.

1.02 DELIVERY, STORAGE, AND HANDLING

- A. Do not store plastic manholes, pipe, and fittings in direct sunlight.
- B. Protect pipe, pipe fittings, and seals from dirt and damage

1.03 REGULATORY REQUIREMENTS

- A. Conform to City of Colonial Heights Department of Utility specifications for materials and installation of the Work of this Section.

1.04 PROJECT RECORD DOCUMENTS

- A. Submit documents under provisions of Section 017000.
- B. Accurately record location of pipe runs, connections, and invert elevations.

PART 2 - PRODUCTS

2.01 SANITARY PIPING

Lateral and main sizes as shown on drawings, with minimum 4" and 6" laterals

A. Ductile Iron

1. Pipe: ASTM A 746, for push-on joints.
2. Standard Fittings: AWWA C110, ductile or gray iron, for push-on joints.
3. Compact Fittings: AWWA C153, for push-on joints.
4. Gaskets: AWWA C111, rubber.

B. PVC Pipe

1. PVC Building Service Pipe and Fittings: ASTM D 1785, Schedule 40 pipe, with plain ends for solvent weld joints with ASTM D 2466, Schedule 40, socket-type fittings. PVC shall not be used at the Heating plant.

2.02 CLEANOUTS

- A. PVC Cleanouts: PVC body with PVC threaded plug. Include PVC sewer pipe fitting and riser to cleanout of same material as sewer piping.

2.03 MANHOLES

- A. Standard Precast Concrete Manholes: ASTM C 478, precast, reinforced concrete, of depth indicated, with provision for sealant joints and shaped flow troughs at the bottom.
- B. Manhole frame and cover shall be HS-20 rated with a minimum 24" clear opening for access.
- C. Manholes with an invert change of 18" or two times the inlet pipe diameter, whichever is greater, shall be provided with drop piping outside of the manhole.
- D. Joints in precast manholes (inside and outside) shall be filled with non-shrink grout and finished smooth.
- E. Manholes shall be coated from inside with vapor/moisture penetration preventing epoxy coating and from the outside with bitumastic/coal tar based waterproof coating.
- F. Pipe connections shall be made with flexible, mechanical clamps, grout and water stop for a leak-proof connection. Install sleeve prior to flexible rubber boot connection at existing structures.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Verify that excavation base is ready to receive work and excavations, dimensions, and elevations are as indicated on drawings.
- B. Beginning of installation means acceptance of existing conditions.

3.02 PREPARATION

- A. Hand trim excavations to required elevations. Correct over excavation with fill material of coarse aggregate.
- B. Remove large stones or other hard matter which could damage drainage tile or impede consistent backfilling or compaction.

3.03 INSTALLATION

- A. Install pipe, fittings, and accessories in accordance with AASHTO Section 30 and manufacturer's instructions. Seal joints watertight.
- B. Place pipe on minimum 4 inch deep bed of VDOT #10 stone dust or sand bed.
- C. Lay pipe to slope gradients noted on layout drawings, with maximum variation from true slope of 1/8 inch in 10 feet.
- D. Provide minimum of 36-inches of cover over sanitary pipes.

- E. Where sanitary laterals exceed 20', provide a cleanout just outside the building in a concrete pad flush with the surface. Laterals shall be a maximum of 50 feet in length.
- F. Install manholes at changes in direction and at a maximum separation of 200 feet.
- G. Install coarse filter aggregate at sides and over top of pipe.
- H. Pipes greater than 20% slope shall be secured with concrete anchors.
- I. Connect to municipal sanitary system.

3.04 FIELD QUALITY CONTROL

- A. Field inspection will be performed under provisions of Section 01 43/45 00.
- B. Perform hydrostatic test for sanitary piping as follows:
 - a. Allowable leakage is a maximum of 50 gallons per inch nominal pipe size, for every mile of pipe, during a 24-hour period
 - b. Close openings in system and fill with water.
 - c. Purge air and refill with water.
 - d. Disconnect water supply.
 - e. Test and inspect joints for leaks.
- C. Manholes: perform hydraulic test according to ASTM C969 (ASTM C969M).
- D. Leaks and loss in test pressure constitute defects that must be repaired and corrected until leakage is within the allowances specified in the ASTM methodology.

3.05 PROTECTION

- A. Protect finished installation.
- B. Protect pipe and filter aggregate cover from damage or displacement until backfilling.

END OF SECTION 333000